

BBC

MIND-READING MACHINES ARE HERE!



WHAT ON EARTH?!

It's life, but not as you know it

FOCUS

BRITAIN'S BEST-SELLING SCIENCE AND TECHNOLOGY MONTHLY

39 IDEAS ABOUT TO CHANGE OUR WORLD

AUDACIOUS INNOVATIONS WHOSE TIME HAS COME

DISCOVER

WHY people
are left-handed
WHAT music helps
your plants grow
HOW spacecraft
dodge asteroids

THE EARTH-LIKE
EXOPLANET WORTH ITS
"WEIGHT IN GOLD"

**MICHAEL
MOSLEY ON:**
HIGH STREET
GENETIC TESTS

THE BBC MICRO IS BACK
Here comes Generation Code

GASTRONOMICAL SCIENCE
Baking tips fresh from the lab





RENAULT
Passion for life

ALL-NEW RENAULT
TWINGO
GO ANYWHERE
GO EVERYWHERE



Renault Summer Season

5 Doors as standard
R&Go Nav App included
Excellent manoeuvrability

0% APR
representative

Discover stunning offers across the range

Book your test drive at renault.co.uk

The official fuel consumption figures in mpg (l/100km) for the All-New Renault Twingo SCe 70 Stop & Start are: Urban 56.5 (5.0); Extra Urban 76.4 (3.7); Combined 67.3 (4.2). The official CO₂ emissions are 95g/km. EU Directive and Regulation 692/2008 test environment figures. Fuel consumption and CO₂ may vary with driving styles, road conditions and other factors.

Finance provided by RCI Financial Services Limited, PO Box 149, Watford WD17 1FJ. Subject to status. Indemnities may be required. Over 18s (excluding Channel Islands). Terms and conditions apply. Visit renault.co.uk for full details. Offers cannot be used with other schemes or finance offers and are available on featured new vehicle when ordered and registered by 30 September 2015. Participating dealers only. Excludes Twingo Expression models. Model shown Dynamique SCe70 Stop & Start has optional Blue non-metallic paint at an additional £225, 16" Emblem alloy wheels at an additional £275, Electric panoramic fabric folding sunroof at an additional £850, White exterior touch pack at an additional £100 and 'Strokes' side decal at an additional £150.

WELCOME



PREDICTING THE FUTURE is tricky. Even Arthur C Clarke, who foresaw modern computing, 3D printing and the mobile phone, got it wrong from time to time. In 1964, in a BBC *Horizon* special at the World Fair, Clarke explained that scientists would be able to bioengineer creatures in the year 2000. On that front he was right. But Clarke then said that these creatures would take the shape of intelligent chimps, bred in the lab to help us with chores. Yet I still have to empty the dishwasher every morning; so on this rare occasion, Clarke was wrong.

It was his great verve for predictions, and his knack for getting them right more often than not, that inspired this issue of the magazine. Rather than look at the world in 50 years time as Clarke did, we've decided to look into the near future to find ideas so compelling that they seem inevitable. Turn to p30 to find out which innovations we chose.

On p56, we remember another visionary – Robert Hooke. Armed with just a microscope and some pencils, Hooke transformed the way we see the natural world with his book *Micrographia*, published 350 years ago this month.

Finally, if reading this felt like a chore, don't fret. Machines that can scan your mind and talk back to it are on the way (p50). Maybe one day we'll be able to send *Focus* directly to your brain (it'd save on postage anyway). Enjoy the issue!

Daniel Bennett

Daniel Bennett, Acting Editor

PS Don't miss our October issue, on sale 17 September 2015



FOCUS DIGITAL

Available for Android • iOS • Kindle Fire
• Kindle e-reader

THIS MONTH WE...



...checked out **Land Rover's cutting-edge virtual reality design cave**, in which they test out new vehicle conceptions before bringing them into the real world.

...chatted to **Taylor Wilson** the Arkansas teenager who successfully produced fusion at 14, after becoming interested in nuclear science at the age of 10. Turn to p98 for our interview with Taylor.



...welcomed our new online editor **Alexander McNamara** to the *Focus* team! Alexander will be in charge of our fabulous website at sciencefocus.com

CONTACTS

ADVERTISING
steve.grigg@immediate.co.uk
0117 314 8365

LETTERS FOR PUBLICATION
reply@sciencefocus.com

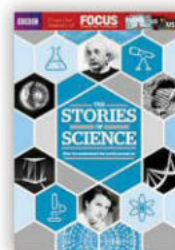
EDITORIAL ENQUIRIES
editorialenquiries@sciencefocus.com
0117 314 7388

SUBSCRIPTIONS
focus@servicehelpline.co.uk
0844 844 0257*

OTHER CONTACTS
<http://sciencefocus.com/contact>

FOLLOW /SCIENCEFOCUS

FACEBOOK
TWITTER
PINTEREST
YOUTUBE



ON SALE NOW!

THE STORIES OF SCIENCE

Our new special issue collects the very best articles from our *How Do We Know?* series.

www.buysubscriptions.com/science

APPEARING IN THIS ISSUE...



Michael Banks

Michael is news editor of *Physics World*. On p56 he reveals

Robert Hooke's key discoveries and takes us on a journey through the history of microscopy.



Rita Carter

Rita is an experienced writer, lecturer and broadcaster who specialises in the human brain. On p50 she takes a look at the machines that can read our minds.



Tom Ireland

Tom is a science writer and managing editor at the Royal Society of

Biology. This month, he rises to the challenge of deciphering DNA in 10 minutes. Turn to p86 to find out more.



Michael Mosley

As a doctor, BBC presenter and willing guinea pig, Michael was

just the person to investigate high street genetic tests on p44. Can they truly offer a glimpse at your future health problems?



WANT TO SUBSCRIBE?

Turn to p28 to save 40% on the shop price of *BBC Focus*



SUBSCRIBER BONUS

On p28, **Marcus Chown** unravels the secrets of quantum theory

* Calls will cost 7p per minute plus your telephone company's access charge. Lines are open weekdays 8am-8pm and Saturdays 9am-1pm. If calling from overseas, please call +44 1795 414 699

CONTENTS SEPTEMBER 2015



ON THE COVER

- 15** EARTH-LIKE EXOPLANET
- 30** 39 IDEAS
- 44** MICHAEL MOSLEY
- 50** MIND-READING MACHINES
- 56** THE NATURAL WORLD
- 65** WHY ARE THERE LEFTIES?
- 74** GASTRONOMICAL SCIENCE
- 79** BBC MICRO:BIT

FEATURES

30 39 IDEAS ABOUT TO CHANGE OUR WORLD

We bring you the most incredible breakthroughs on the horizon

44 HIGH STREET GENETIC TESTS

Are £125 tests really a reliable health aid? Michael Mosley reports

50 FACEBOOK WANTS TO READ YOUR MIND

Machines can decipher your brain's inner workings

56 NATURE'S HIDDEN BEAUTY

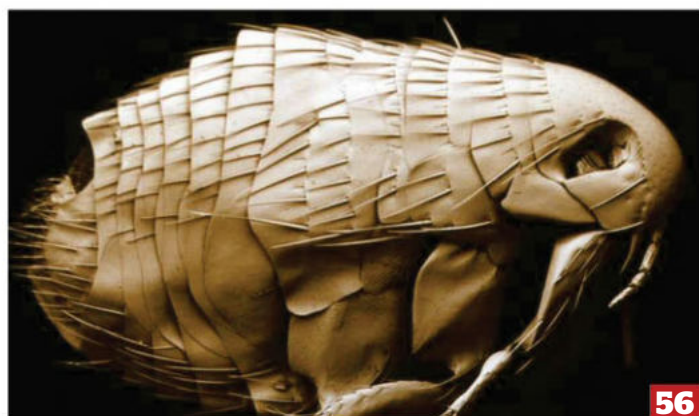
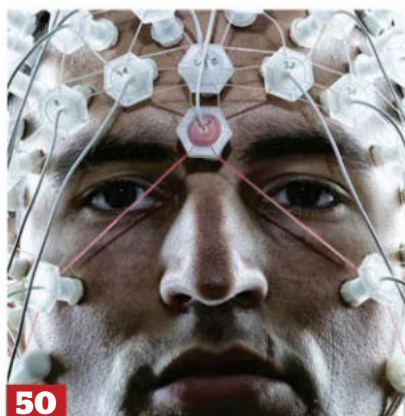
Earwigs, fleas and flies as you've never seen them before

74 THE SCIENCE OF SOGGY BOTTOMS

The Great British Bake Off is back! We reveal the chemistry behind the cakes

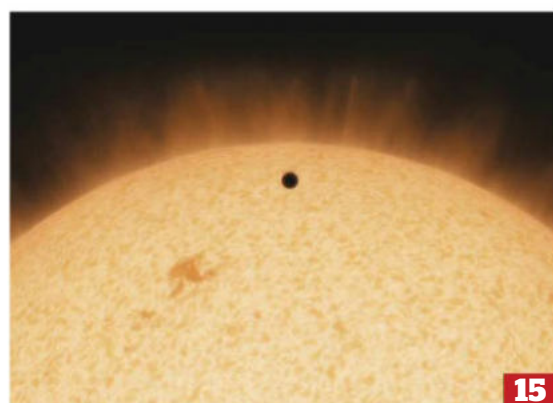
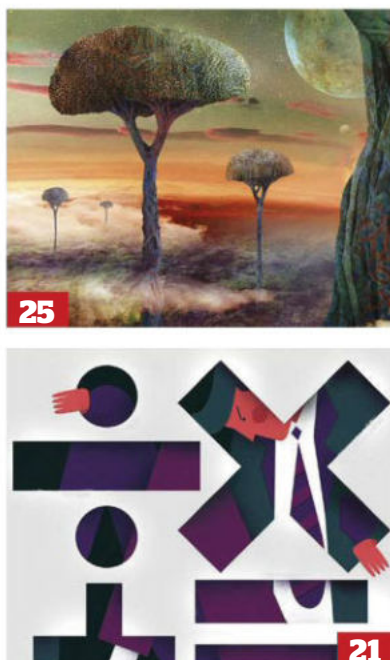
86 DNA IN 10 MINUTES

This clever little molecule is present in every living thing, and can help us decipher evolution, ancestry and more



28 SUBSCRIBE TODAY!
AND SAVE 40%





DISCOVERIES

15 NEW EXOPLANET DISCOVERED

A world outside our Milky Way in the Cassiopeia constellation

18 BROWN DWARF HAS AURORA

Further evidence that 'failed stars' are massive planets

20 MUSICAL TALENT COULD BE INHERITED

Practice doesn't make perfect

22 SLEEP HELPS MEMORY

A good night's rest helps your brain remember

COLUMNS

17 DAVID SHUKMAN

New Horizons delivered surprise after surprise

21 ROBERT MATTHEWS

Maths education needs to keep up with the times

23 HELEN CZERSKI

There's a trick to dealing with condensation on mirrors

25 STEPHEN BAXTER

Are there trees in space?

106 HOLLYWOOD SCIENCE

The Man From U.N.C.L.E.

TECH HUB

79 BBC MICRO:BIT

One million students will get one of these devices and we're jealous

81 BILL THOMPSON

Immersive films could revolutionise the cinema

83 APPLIANCES OF SCIENCE

A radar bike light, a diving drone, and a smartphone for less than £50

84 ULTIMATE TEST

Back to school gadgets

TO DO LIST

93 PICK OF THE MONTH

Don't miss BBC's Make It Digital season running through September

94 WATCH

This month's best TV

96 LISTEN/TOUCH

Radio shows, smartphone and tablet apps

97 VISIT

Great talks and days out

98 READ

The latest science books

PLUS...

6 MEGAPIXEL

Jaw-dropping science images from round the world

12 REPLY

Find out what's been in the *Focus* postbag this month

65 Q&A

What music helps plants grow, how spacecraft avoid asteroids, could dinosaurs survive today and much more

105 MINDGAMES

Give your brain a workout with this month's crossword



BE AN INSIDER

We want to know what you think – the more we know about you, the better placed we are to bring you the best magazine possible. So join our online reader panel, 'Insiders'. Log on to www.immediateinsiders.com/register to fill out a short survey and we'll be in touch from time to time to ask for your opinions on the magazine. We look forward to hearing from you.

Awe-inspiring images from the world of science

MegaPixel

Fuzzy fish

THIS STARTLED FACE belongs to a Japanese warbonnet.

The fish takes its name from the colourful tassels, or 'cirri', all over its body, which resemble the feathers on a Native American headdress.

"All warbonnets have elaborate head cirri," explains Jeff Marliave from Vancouver Aquarium's Marine Science Centre. "These help the fish to blend in with the fuzzy growths on the rocks they hide around."

Behind the decorated head, these fish are eel-like and can grow up to 40cm in length. They are reclusive, spending most of their time lurking among rocky reefs and boulders, and generally feed on small invertebrates such as anemones, worms and molluscs.

Japanese warbonnets are found in the sea between Japan and the east coast of Russia, like this one photographed in Rudnaya Bay near Vladivostok.

PHOTO: ANDREY SHPATAK/WENN.COM





+ MegaPixel

Out of the blue

EARLIER THIS YEAR, beaches on the west coast of the US were transformed into a translucent carpet of bizarre blue creatures. Although closely resembling jellyfish, each of these *Velella velella* is actually composed of a colony of individual animals. Their prey – usually plankton – is caught using stinging tentacles, but they are not considered dangerous to humans.

V. velella ride currents with the aid of a sail made from a substance called chitin. This sail gives them their common name of 'by-the-wind-sailors'.

"I find it both incredible and tragic that millions of these beautiful and delicate floating colonial organisms, with their specialised structures for sailing, feeding, and reproduction, are adrift out in the open sea," says Dr Steven Rumrill of the Oregon Institute of Marine Biology. "And then by some nuance of the winds they become concentrated along the shore and cast up on the beaches where they dry out, die, and become a spectacle for beach walkers."

PHOTO: TIFFANY BOOTHE





MegaPixel

Digit doppelgangers

PROSTHETICS TECHNOLOGY has come a long way since the days of the wooden leg. These extremely realistic digits are products of the 'livingskin' range by Touch Bionics.

As well as fingers, the livingskin range also includes entire limbs, and all the silicone devices are custom-made to match the patient's skin tone. They can be painted to include features such as freckles, hairs and even tattoos!

"As the product is taken from actual impressions of the wearer's sound limbs, the shape, size and features are

a close match," says Karen Hakenson at Touch Bionics. "An impression is taken to create a mould that is then painted with multiple layers to give the prosthesis the appearance of appropriate skin depth. It is also painted from the inside out to ensure the paint does not wear off from day-to-day use."

Although such prostheses are primarily purchased for cosmetic reasons, the devices are capable of performing basic actions such as pushing, pulling and typing.

PHOTO: GETTY





REPLY

Your opinions on science, technology and *BBC Focus Magazine*



SEND TO...

reply@sciencefocus.com
BBC Focus Magazine, Tower House,
Fairfax Street, Bristol, BS1 3BN
@sciencefocus
www.facebook.com/sciencefocus

Letters may be edited for publication

MESSAGE OF THE MONTH



If Doc Brown's antics caused any trouble, the Universe would simply de-exist him, argues Oisín McGuigan

Time troubles

I ENJOYED THE article 'The trouble with time travel' (Summer, p40). I've always had an interest in time travel and paradoxes, as seen in shows like *Doctor Who* and *Back To The Future*. I always attempted to solve paradoxes by thinking of the Universe as an entity that is able to change things happening through time. Instead of the misfiring gun in Igor Novikov's solution, I always thought that if someone was going to kill their grandfather and begin a paradox, the Universe would simply follow a different timeline where neither the grandfather or the time traveller existed. You can't go and kill your grandfather – you and your grandfather don't exist.

I really enjoy the education and brain exercise your articles deliver on a steady basis.
Oisín McGuigan, aged 13



Write in and win!

The writer of next issue's Message of the Month wins a Divoom Voombox Party worth £99.99. This 2.1-channel weatherproof speaker is ideal for barbecues and camping: simply pair it with your smartphone or tablet via Bluetooth or NFC and it'll pump out 20W of sound for up to eight hours on a single charge. For more info see divoom.com



The end of the Universe?

I'm always fascinated by the variety of subjects covered in each edition of *Focus*. This month I had to smile at Robert Matthews (August, p23): "Maths can explain why 'silly season' formulas are complete nonsense." Initially, I thought it was just amusing, but reading on I wondered if he was forewarning the reader for the revelations on page 26, which revealed a theory that our Universe will ultimately tear itself apart.

Why do some scientists obsess about the demise of the Universe? They're slightly more technically qualified than the Hyde Park sandwich-board men predicting the end of the world, but both are pure speculation! Nobody understands the complexity of the Universe and the billions of variables that interact within it. I feel the end of space theorists are merely contributing to the 'silly season' formulas.

John Pawson, via email

Hearing impaired

As an long-time reader of *Focus* I devour every page with the appetite of a blue whale. Reading July's issue, however, I noticed an interpretation of sound that was somewhat off. In the 'Q&A' section, there is an article comparing the technical characteristics of a Formula 1 car with those of a Formula E car, and a graph is presented to show the difference in the sound output of each vehicle – 134dB for the F1 vs 80dB for the Formula E.

The decibel scale, however, is a logarithmic way of describing a ratio, and



The E in Formula E stands for 'easier on the eardrums'

the sound level doubles with each 3dB increase. Therefore the circular graph showing the difference between 134 and 80 is not accurate, as there's very little comparison between the two decibel levels. 80db is below the mandatory level for the use of hearing protection (85dB), whereas if one were exposed to 134dB for very long, permanent hearing loss would most likely occur.

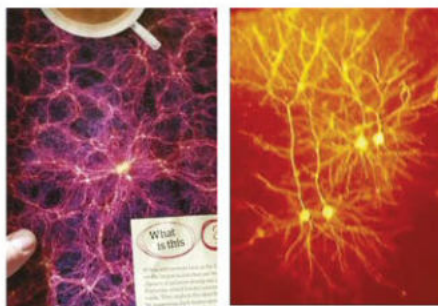
Will McLellan, Dublin

Parallel lines

For my 40th birthday, my work colleagues subscribed me to *Focus* for 12 months. I received my first last month and was blown away. I have attached two photos. One from your last issue shows clusters of galaxies, while the other shows neurones in the human body.

I found the similarity startling. I'm a physiotherapist and parallels pop up all the time between the human body and the larger Universe. I intend to put pictures of each side-by-side in my clinic.

John Casey, Tipperary



Galaxy clusters (left) and neurones (right). Spooky, eh?

Tip of the iceberg

Please can you explain how a turning iceberg can generate energy comparable to that of an atomic bomb, as stated in 'Megapixel' (Summer, p6)?

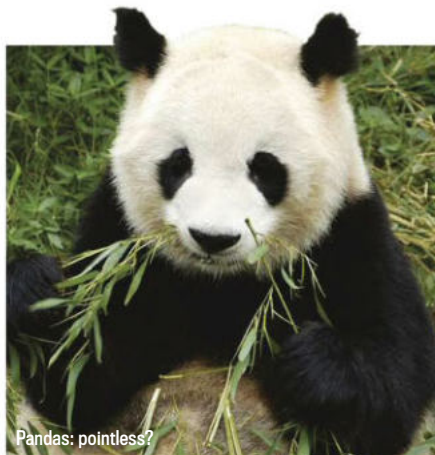
Pamela Millyard, Suffolk

The reason capsizing icebergs release so much energy as they 'flip' is their large mass. Their huge size allows them to carry a vast amount of gravitational potential energy, which is the product of mass x height x the strength of gravity. While all icebergs float around with the majority of their mass submerged beneath the water's surface, some drift in an unstable orientation and can be prone to capsizing, releasing huge amounts of energy as they flip. However, the energy is released over the course of several minutes rather than all at once, as with an atomic bomb.

Jason Goodyer, commissioning editor

Paranoid android

Stephen Baxter's column on living through the sixth great extinction event



Pandas: pointless?

omitted one possibility that may shape this event for us: artificial intelligence. He argued that it is unlikely that we would allow the evolution of a competitor as smart as we are. However isn't this what we are heading towards with AI?

Could it be that once we create machines with equal or higher intelligence to us, our worst sci-fi fears are realised? What if the machines decide we are a danger to ourselves and need to be 'controlled' as we control vermin – or worse, a cancer that needs wiping out?

The prominent point raised though is that we are spending a lot of effort saving 'cuddly' creatures such as pandas. Arguably pandas are predisposed to extinction, when highly beneficial creatures that may not be so palatable have more of a fighting chance. Should we not concentrate on saving the life forms that will enable life to spring back faster?

Darren Loczy

Dreams of dinos

Reading 'We can build Jurassic World' (July, p35) and the piece about 'designer babies' (p15) got me thinking. Will we be able to make designer dinosaurs like those in *Jurassic World*, where they make their own species by modifying and combining the DNA of various dinosaurs? If so, does this mean that the prospect of our own personal dinosaurs that we all dreamed about as children could become a reality?

How scary having your own dinosaur looking over you every morning is up for debate, of course!

Matthew Barber

Oops!

- Our timeline on p16 of the July issue said Dolly the sheep was "the first ever animal to be cloned". Dolly was actually the first mammal cloned from a somatic (non-embryonic) body cell. The cell was from the donor sheep's mammary gland – hence the name Dolly, in honour of Dolly Parton.

FOCUS

SCIENCE AND TECHNOLOGY

EDITORIAL

Acting Editor **Daniel Bennett**
Production Editor **Alice Lipscombe-Southwell**
Commissioning Editor **Jason Goodyer**
Online Editor **Alexander McNamara**
Editorial Assistant **James Lloyd**
Editorial Consultant **Graham Southorn**
Science Consultant **Robert Matthews**
Contributing Editor **Emma Bayley**

ART & PICTURES

Art Editor **Joe Eden**
Designer **Jon Rich**
Picture Editor **James Cutmore**

CONTRIBUTORS

Acute Graphics, Michael Banks, Stephen Baxter, Hayley Birch, Susan Blackmore, Dean Burnett, Rita Carter, Brian Clegg, Helen Czerski, Russell Deeks, Andrew Gibbs, John Gribbin, Alastair Gunn, Tori Herridge, Afsaneh Khetrapal, Tom Ireland, Mark Lorch, Andrew Lyons, Robert Matthews, Gareth Mitchell, Michael Mosley, Lisa Moses, Matt Murphy, Dale Edwin Murray, Henry Nicholls, Catherine Offord, Helen Pilcher, Andy Potts, Dean Purnell, Bethany Rielly, Kate Russell, David Shukman, Colin Stuart, Bill Thompson, Luis Villazon

ADVERTISING & MARKETING

Advertising Manager **Steve Grigg**
Brand Sales Executives **Alia Coster**, **Anastasia Jones**
Senior Classified Executive **Jenna-Vie Harvey**
Newstrade Manager **Rob Brock**
Subscriptions Director **Jacky Perales-Morris**
Direct Marketing Manager **Kellie Lane**

MOBILE

Product and Development Director **Richard Fennell**
Head of Apps and Digital Edition Marketing
Mark Summerton

INSERTS

Laurence Robertson 00353 876 902208

LICENSING & SYNDICATION

Director of Licensing and Syndication **Tim Hudson**
International Partners Manager **Anna Brown**

PRODUCTION

Production Director **Sarah Powell**
Production Coordinator **Emily Mounter**
Ads Services Manager **Paul Thornton**
Ad Coordinator **Jade O'Halloran**
Ad Designer **Matt Gynn**

PUBLISHING

Publishing Director **Andy Healy**
Publisher **Jemima Ransome**
Chairman **Stephen Alexander**
Chief Executive Officer **Tom Bureau**
Deputy Chairman **Peter Phippen**
Managing Director **Andy Marshall**

BBC WORLDWIDE, UK PUBLISHING

Director of Editorial Governance **Nicholas Brett**
Director of Consumer Products and Publishing
Andre Moultrie
Head of UK Publishing **Chris Kerwin**
Publisher **Mandy Thwaites**
Publishing Coordinator **Eva Abramik**
Contact: UK.Publishing@bbc.com
www.bbcworldwide.com/uk-anz/ukpublishing.aspx

EDITORIAL COMPLAINTS

editorialcomplaints@immediate.co.uk



Audit Bureau of Circulations
63,204 (combined; Jul-Dec 2014)

Annual subscription rates (inc P&P):
UK/BFPO £55.25; Europe & Eire Airmail
£58.50; Rest of World Airmail £63.
BBC Focus Magazine is published by Immediate Media
Company London Limited under licence from BBC
Worldwide who help fund new BBC programmes.



© Immediate Media Co Bristol Ltd 2015. All rights reserved. Printed by William Gibbons Ltd.

Immediate Media Co Bristol Ltd accepts no responsibility in respect of products or services obtained through advertisements carried in this magazine.

Spirit in the Sky

THE NEW **C8** FLYER AUTOMATIC – VINTAGE BLACK EDITION – 44MM

Inspired by the Best of British Aviation



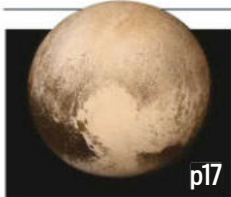
CHR. WARD
LONDON

EXCLUSIVELY AVAILABLE AT christopherward.co.uk

DISCOVERIES

News and views from the world of science

EDITED BY
JASON GOODYER



p17

PLUTO FULL OF SURPRISES

David Shukman tells us his thoughts about the New Horizons mission to Pluto



p18

TWEET TALK

Birds can learn to recognise the alarm calls of other species



p24

THE WORM HAS TURNED

The ageing process in nematodes has been halted by scientists

THE BIG STORY

NEARBY EXOPLANET A 'GOLDMINE' OF NEW SCIENCE

Astronomers have spotted a new world outside our Milky Way



HD 219134b

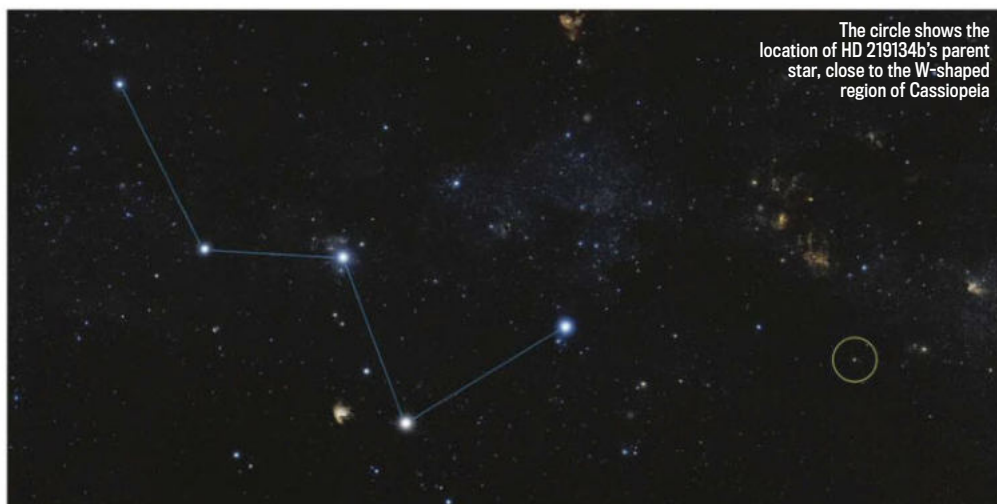
THE EARTH has a new next-door neighbour. Astronomers using NASA's Spitzer Space Telescope have confirmed the discovery of the nearest rocky planet to our Solar System. Dubbed HD

219134b, the exoplanet (a planet outside our Solar System) lies in the Cassiopeia constellation just 21 light-years away. The planet is 4.5 times the mass of the Earth and completes an orbit around its parent star in a nippy three days. However, the



Artist's impression of HD 219134b passing its parent star

PHOTO: NASA



The circle shows the location of HD 219134b's parent star, close to the W-shaped region of Cassiopeia

GOOD MONTH/ BAD MONTH

It's been good for:

COUCH POTATOES

If your idea of a good workout involves walking to the cupboard to get another doughnut, read on. Scientists from the University of Southampton have developed a molecule that can mimic the positive effects of exercise. Dubbed 'compound 14', the molecule reduced blood glucose levels, improved glucose tolerance and promoted weight loss in obese mice.



SARCASTIC SO-AND-SOS

It may be derided as the lowest form of wit, but it seems sarcasm may help to improve our creativity. Studies carried out by Harvard and Columbia Universities have found that those who either used or were exposed to sarcasm performed up to three times better in subsequent creativity tests.

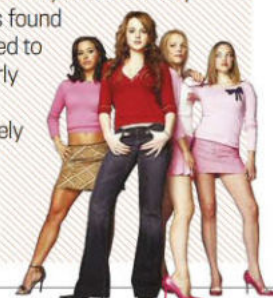
It's been bad for:

PERFECTIONISTS

IF YOU INSIST on things being 'just so' it might be worth letting things slide every once in a while, especially when it comes to the workplace. Researchers from the York St John University have found that perfectionists are more likely to burnout. The effect is due to the stress of consistently setting high standards and striving for unachievable goals.

COOL KIDS

IT SEEMS THAT *Mean Girls* got it wrong. Being one of the cool kids isn't all it's cracked up to be. A decade-long study carried out by the University of Virginia has found those who tried to act cool in early adolescence were more likely to experience problems in adulthood.



→ planet is situated too close to its star to sustain life.

HD 219134b is the closest exoplanet to Earth that has been detected transiting, or crossing in front of, its star. This makes it an ideal candidate for research.

"Thanks to NASA's Kepler mission, we know super-Earths are ubiquitous in our Galaxy, but we still know very little about them," says researcher Michael Gillon. "Now we have a local specimen to study in greater detail. It can be considered a kind of Rosetta Stone for the study of super-Earths."

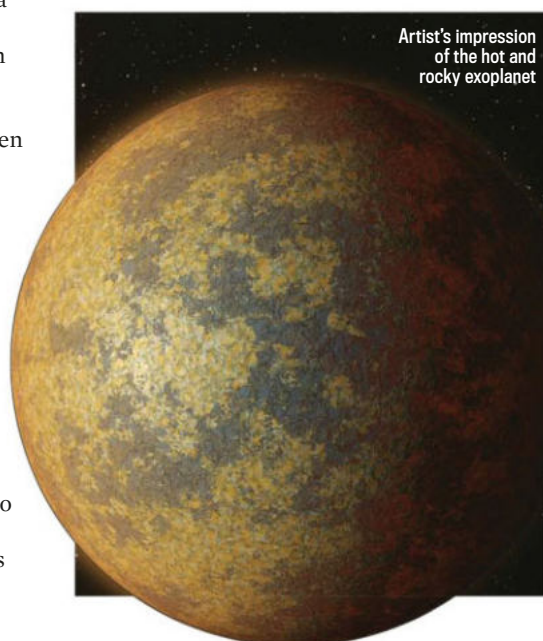
Only a small percentage of exoplanets can be detected transiting their stars, thanks to their orientation relative to Earth. Transit occurs when the planet is positioned between its star and Earth, slightly dimming the light coming from its star. By measuring the changes in light, scientists are able to determine the size of the planet and gather clues about its composition.

"Transiting exoplanets are worth their weight in gold because they can be extensively characterised," says researcher Michael Werner. "This exoplanet will be one of the most studied for decades to come."

The planet was initially discovered by the HARPS-North instrument on the Galileo National Telescope located in the Canary Islands. Then, using infrared measurements from Spitzer, researchers were able to

determine the planet's size at roughly 1.6 times that of Earth. Combining the size and mass allowed them to estimate the density to be 6g per cubic centimetre, confirming HD 219134b is a rocky planet.

Scientists will now observe HD 219134b with both ground- and space-based telescopes to gather more information about it. It could also potentially be studied in greater detail by the James Webb Space Telescope when it launches in 2018, they say.



Artist's impression of the hot and rocky exoplanet

TIMELINE

A brief history of exoplanets

1992

Astronomers Aleksander Wolszczan and Dale Frail track down PSR1257+12b. This is the first planet ever discovered outside our Solar System.

1999

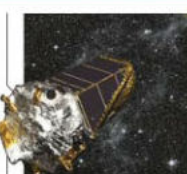
David Charbonneau and Greg Henry independently observe HD209458b, the first transiting exoplanet. It is also the first exoplanet known to have an atmosphere.

2001

Astronomers from Geneva University discover HD28185b, the first exoplanet found to be in the habitable zone around a star where liquid water can exist.

2009

NASA's Kepler mission (pictured) is launched. It surveys a region of the Milky Way with the goal of discovering Earth-like planets that are orbiting other stars.



Pluto proved to be full of surprises

DAVID SHUKMAN
The science that matters



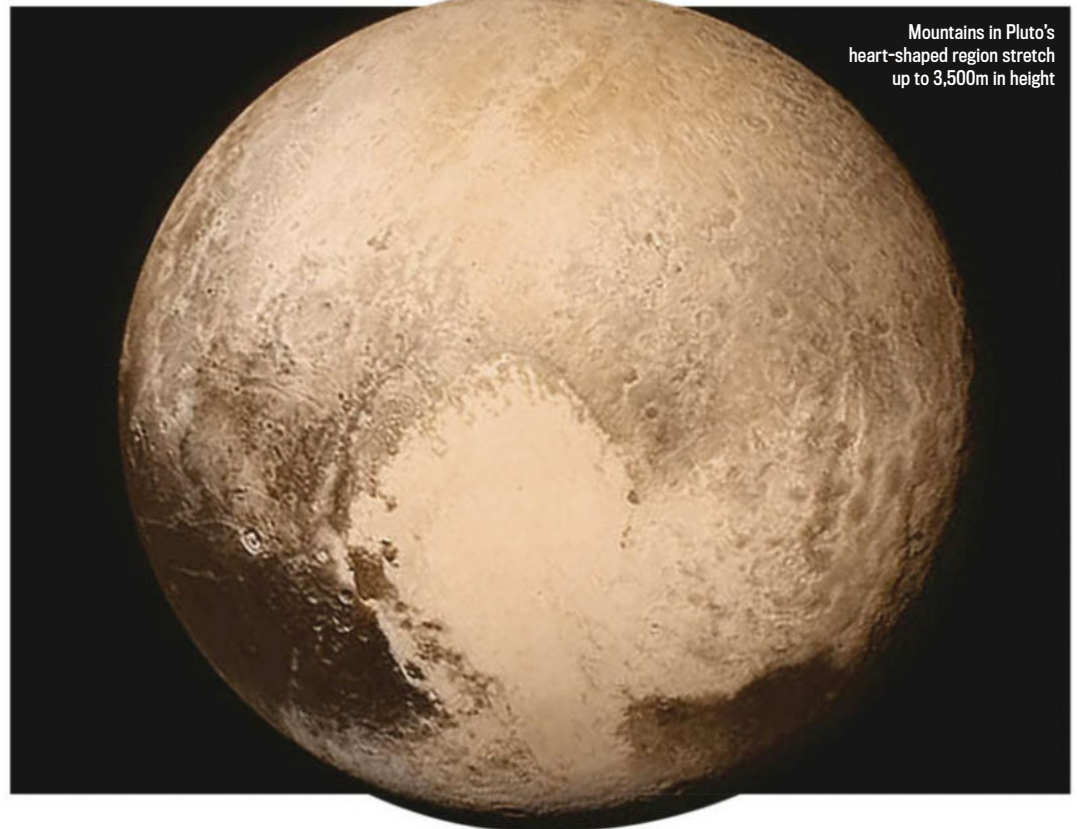
THE AUDITORIUM WAS packed for an electrifying chapter in space exploration: the release of the first close-ups of Pluto. I was sitting with the engineers running NASA's New Horizons spacecraft. They had waited nine-and-a-half years for this moment and were jumpy with nerves and excitement.

And so was I. Make notes or tweet? I couldn't decide.

Nearby were relatives of Clyde Tombaugh, who discovered Pluto in 1930. Some of Clyde's ashes were on board the probe as it skimmed past the distant world. His son Al told me that "a little piece of Dad is now at the edge of the Solar System".

A group of schoolchildren added their voices to the fervour. Dressed in Pluto T-shirts, they were born on the day that New Horizons was launched in 2006 – a reminder of the extraordinary duration of the mission, and of the patience required to see results.

Each image brought surprise after surprise. In one corner of the orange-pink sphere of Pluto, mountains made of ice stood as tall as the Rockies. A vast plain, which should be pockmarked with craters, looked eerily smooth. There must be some geological process at work, but no-one knows what. There may



Mountains in Pluto's heart-shaped region stretch up to 3,500m in height

even be a source of heat inside Pluto driving the changes at the surface, so it's possible that there may also be liquid water.

It had been assumed that the fringe of the Solar System was frigid and dull. But even a seasoned sci-fi writer would have had trouble dreaming up what New Horizons uncovered. For Alan Stern, Principal

Investigator of New Horizons, the discoveries took immense perseverance. Year after year, his proposals to visit Pluto were rebuffed. But he did not give up.

"This isn't about rewriting the textbooks, it's about writing them," he said when I grabbed a few words with him.

Determination, grit and Zen-like calm are not qualities

that many people might associate with research. But these qualities made all the difference. That's just something to bear in mind when you gaze at each new shot of Pluto.

DAVID SHUKMAN is the BBC's Science Editor. @davidshukmanbbc

WHO'S IN THE NEWS?

Johann-Dietrich Woerner

Newly appointed
Director General
of the European
Space Agency

What did he say?

Woerner has proposed that we build a 'village' on the far side of the Moon.

Why would we want to do that?

The village could serve as a testing base for future manned missions to Mars, where new technologies could be trialled. It could also be used as a vantage point for telescopes to look deep

into the Universe, he says.

How would we build it?

Woerner suggests that a large-scale 3D printer could be transported to the Moon and used to create the base.

Who would build it?

He hopes that countries from all over the world will pitch in. He believes that cooperating on

such a large-scale project could help to strengthen ties between different nations.

When is it happening?

So far the whole concept is very much in the idea stage. No-one has put up any money or formulated any concrete plans. However, Woerner hopes his comments will inspire others to think big.



1 MINUTE EXPERT

EMDrive



What's that?

A controversial 'engine' proposed by British aerospace engineer Roger Shawyer that theoretically generates thrust by bouncing microwaves around within a closed container. Recently, the University of Dresden's Martin Tajmar claimed to have built a functioning EMDrive.



Wow. That sounds fantastic

There's more. As the microwaves could be generated using solar power, the device could potentially operate indefinitely without the need for fuel. It is also potentially capable of travelling incredibly fast, allowing a spacecraft to travel to Mars in as little as two months.



That sounds too good to be true. What's the catch?

The engine's design seems to violate the conservation of momentum. This fundamental tenet of physics states that if something is being propelled forwards, then something needs to be pushed in the opposite direction.



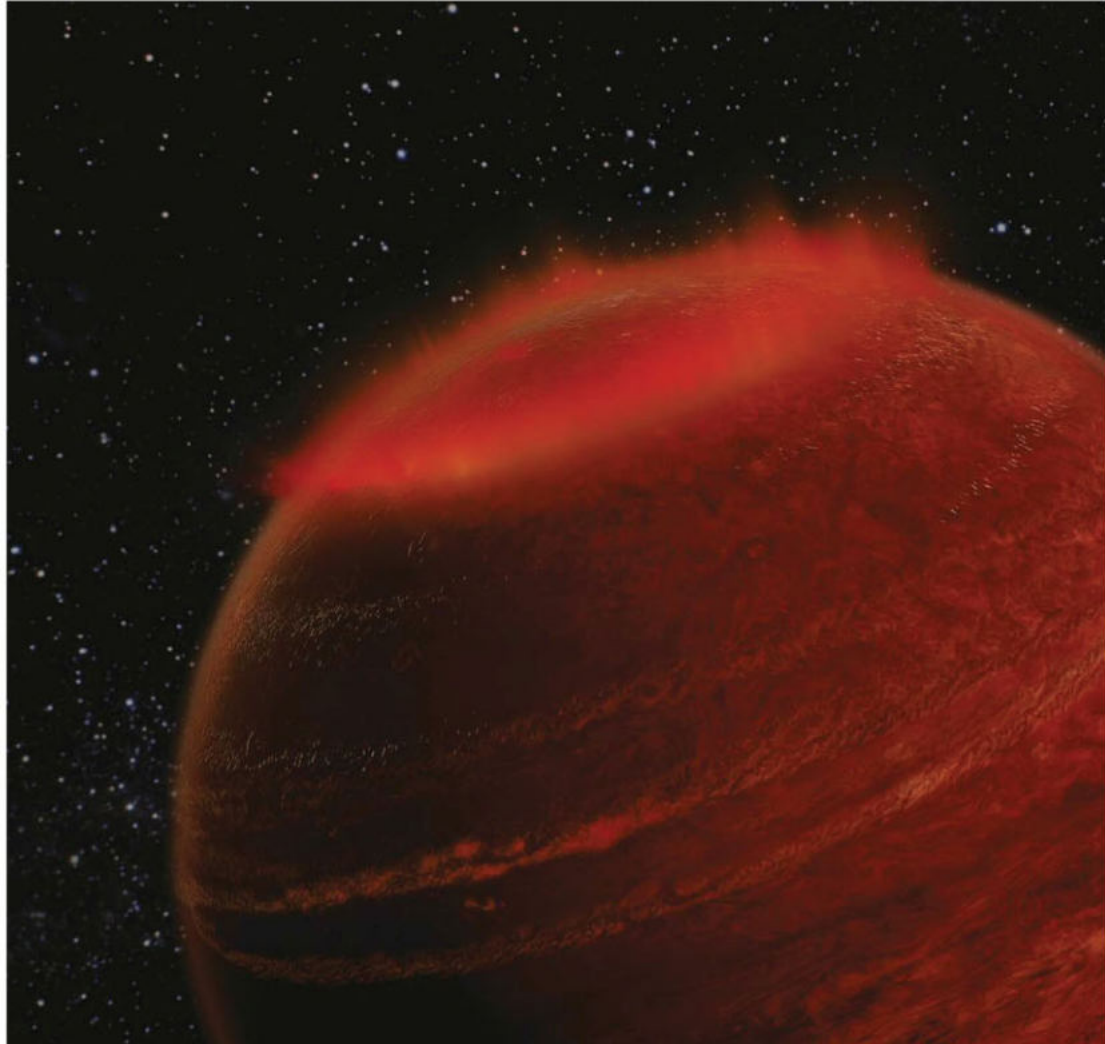
So, should I pack a bag?

I wouldn't if I were you.

The research paper is yet to undergo peer review and several critics have already raised issues with Tajmar's methodology.



While the engine looks pretty innocuous, it could allow space travel at super-fast speeds



SPACE

Intense aurora around brown dwarf

IT LOOKS LIKE the Northern Lights have some competition. Researchers have spotted an intense halo-like aurora encircling a brown dwarf 18 light-years away in the Lyra constellation. The impressive light display was observed by researchers from the Universities of Sheffield and Oxford using a combination of radio and optical telescopes. It is

thought to be around one million times brighter than the Earth's version.

"Brown dwarfs span the gap between stars and planets and these results are yet more evidence that we need to think of brown dwarfs as beefed-up planets, rather than failed stars," says the University of Sheffield's Dr Stuart Littlefair. "We already know that brown dwarfs have cloudy

atmospheres – like planets – although the clouds in brown dwarfs are made of minerals that form rocks on Earth. Now we know brown dwarfs host powerful auroras too."

The auroral displays occur when charged particles enter a planet's magnetic field, get accelerated along its magnetic field lines to the poles and then collide with gas atoms in the atmosphere.

THEY DID WHAT?!

Wild birds taught 'foreign' languages

What did they do?

A team at the Australian National University trained fairy wrens to understand the warning

calls of other species by playing recordings, while throwing a model glider of a sparrowhawk over them.

What did they find?

After just eight playbacks, the fairy wrens were able to associate the warning calls with danger and fled upon hearing them. The same effect was not seen when

other unfamiliar warning calls that had not been associated with the model sparrowhawk were used.

"Recognising other species' calls is a remarkable ability, because there are lots of species in a natural community, and lots of different types of calls. It's like understanding multiple foreign languages," says Prof



PATENTLY OBVIOUS with James Lloyd

Inventions and discoveries that will change the world

Nuclear planes

COULD AIR TRAVEL be powered by lasers and nuclear explosions? A patent from Boeing reveals an engine that uses laser beams to vaporise a fuel pellet. This pellet – possibly a blend of deuterium and tritium – would undergo nuclear fusion, generating enough thrust to power the craft. High-energy neutrons produced by the fusion reaction could be reacted with uranium-238 to power a turbine, recharging the lasers and creating a self-sustaining device.

Patent application number:
US 9,068,562

Damage-proof data

WE ALL KNOW how annoying it is to lose files, so how about etching all your digital documents onto an indestructible disk? French company Fahrenheit 2451 has patented a way to laser-engrave microscopic text and images onto a transparent, synthetic sapphire wafer. A 20cm disk can store up to 10,000 pages of text, viewable under a magnifying glass. The company claims that the Nanoform disks can last for millennia – perfect for preserving those selfies.

Patent number:
WO 2009092794

These impressive aurora displays are further evidence that brown dwarfs should be considered huge planets, rather than failed stars

The team deduced the existence of the aurora after noticing a pulse of radio waves beaming out of the brown dwarf, dubbed LSRJ 1835+3259, as it rotated around every 2.84 hours. Then, using an optical telescope, they found that the object's brightness varied in the same period. They determined that this was likely to be caused by electrons hitting the hydrogen-dominated atmosphere of the brown dwarf and producing the aurora.

"In science, new knowledge often challenges our

understanding. We know how controversial the situation was with Pluto, where astronomers had to look hard to try to decide if it is fundamentally one of the major planets of the Solar System, or the first of the Kuiper Belt objects," explains the University of Oxford's Garret Cotter. "Now, up at the other end of the size scale, we are challenged by seeing objects that traditionally would have been classified as stars, but seem to be showing more and more properties that make them look like super-sized planets."

Robert Magrath, who took part in the study.

Why did they do that?

As well as helping scientists to understand how 'language' functions in the animal kingdom, the research could be used to help train captive animals to recognise signals of danger before they are released into the wild.



The fairy wren is common across southeastern regions of Australia

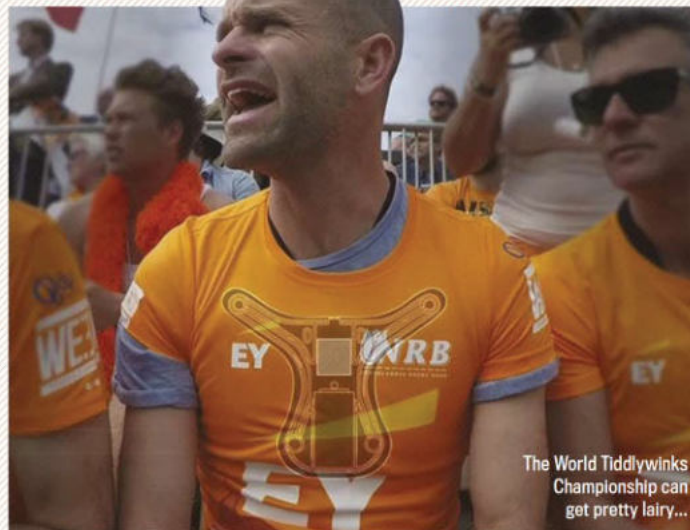
Shakin' shirts

SITTING IN THE stands and cheering on your favourite team is all well and good, but what if you really want to feel what the players are going through? A vibrating shirt developed by Wearable Experiments promises to put sports fans right in the centre of the action.

The technology collects information about each player's impacts and heartbeat, sending it to a smartphone app that's connected to the shirt via Bluetooth. Haptic feedback motors embedded in the shirt then convert the data into physical sensations in real time, allowing you to feel the impact of a crunching tackle or a goal-denying save. It'd even let you experience more subtle sensations such as the fluttering of nerves before a crucial penalty kick.

The shirts, recently demonstrated by the Dutch Ladies Sevens Rugby team, could presumably be extended to other garments. Let's just hope they're not planning on making spectator headwear for boxing matches...

Patent pending



The World Tiddlywinks Championship can get pretty lairy...

ASTRONOMY

Map of Milky Way shows stars have 'migrated'

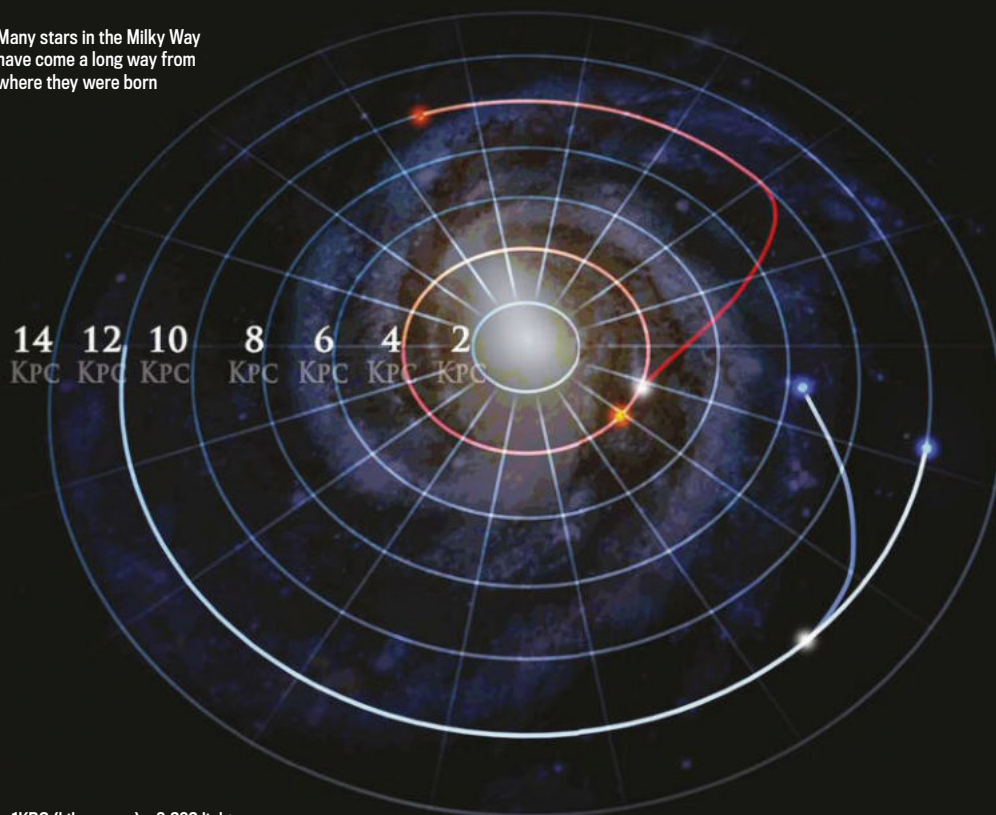
IT SEEMS STARS really do wander. Researchers from the Sloan Digital Sky Survey have created a detailed map of the Milky Way that shows nearly a third of its stars have 'migrated' great distances.

"In our modern world, many people move far away from their birthplaces, sometimes halfway around the world," says researcher Michael Hayden. "Now we're finding the same is true of stars in our Galaxy – about 30 per cent of its stars have travelled a long way from where they were born."

To build the map, the team used the Apache Point Observatory Galactic Evolution Explorer (APOGEE) spectrograph to observe 100,000 stars over a four-year period. They were able to determine the different elements in the atmosphere of each star by looking at their spectra – measurements of how much light the star gives off at different wavelengths. Various peaks and troughs in the spectra reveal which elements and compounds the stars contain.

Stars create heavier elements in their cores, and when they die, those heavier elements go back into the

Many stars in the Milky Way have come a long way from where they were born



1KPC (kiloparsec) = 3,262 light-years

gas from which the next stars form. This means each generation of stars has a higher proportion of heavier elements than the last. As the rate of star formation varies across the Galaxy, the quantity of heavier elements in stars also varies. This means

astronomers can determine what part of the Galaxy a star was born in by measuring the heavy elements it contains.

When building the map, the team found 30 per cent of stars had compositions indicating that they were formed in parts of the Galaxy far from

their current positions. They found the stars moved closer or farther from the galactic centre with time. These in-and-out motions are likely caused by irregularities in the galactic disc, such as the Milky Way's famous spiral arms, the researchers say.

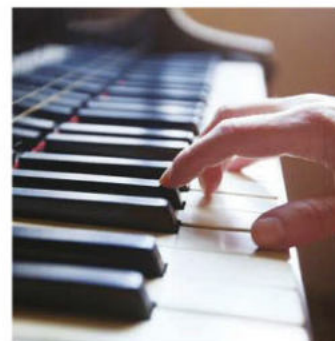
NEUROSCIENCE

Brain regions that determine musical talent identified

IT MIGHT BE time to list your old guitar on eBay and take up another hobby, because when it comes to learning a musical instrument, it seems practice *doesn't* make perfect. Researchers at McGill University in Canada have found evidence that musical 'talent' is, instead, related to specific patterns of brain activity. The team put young

adults with little or no musical background through six weeks' musical training, during which time they were required to learn simple piano pieces. FMRI scans showed that the type of activity in the auditory cortex and hippocampus – parts of the brain linked to memory and the processing of sounds – reliably indicated how quickly an individual would learn.

"Predisposition plays an important role for auditory-motor learning that can be clearly distinguished from training-induced plasticity," says McGill's Robert Zatorre, who led the study. "Our findings pertain to the debate about the influence of 'nature or nurture', but also have potential practical relevance for medicine and education."





ROBERT MATTHEWS

MATHS EDUCATION DOESN'T ADD UP

Governments should scrub boring equations from schools

WITH THE START of the new school year, a whole generation will begin a journey of exploration culminating in the discovery that they hate maths.

Everyone has their reasons why they despise the subject. But many of them were crystallised in one of the social media sensations of the summer, surrounding a girl called Hannah. Apparently, she had bought a bag of sweets, half a dozen of which were orange, and had eaten two of them. Hardly headline-grabbing stuff, but here's the thing: while the number of sweets in the bag wasn't clear, there was a one in three chance that both of Hannah's sweets were orange. And that meant the number of sweets in the bag was given by... a quadratic equation.

Who cares? The examiners who'd devised this ludicrous scenario for a GCSE maths paper, that's who. That meant that a host of sixth-form departments, universities and future employers also wanted to know all about Hannah and her bag of sweets too. Except they didn't, of course. It's just as well, as thousands of students taking the exam couldn't make head nor tail of it, and took to social media to complain.

I share their frustration, though possibly for somewhat different reasons. For me, this hopeless question speaks volumes about what's gone wrong with maths education over the years.

Imagine if English exams consisted entirely of questions like: 'Create sentences out of the following words', or 'Identify the tense in the following phrases'. Would we say that those who succeeded could express themselves clearly, or understand an argument?

Yet that's where we are with maths, where the syllabus is crammed with useless and demotivating stuff whose only merit is that it can be tested in the standard way.

Real maths isn't much like the stuff taught in schools. Sure, there are percentages, but most of it is far more interesting. And, critically, it makes use of computers. They do the grunt work of solving equations, while people get to do the creative stuff of capturing the essence of a problem, getting it into a format a computer can understand, and making sense of the outcome.

That's why, to quote the mathematician Conrad Wolfram, we need to "stop teaching calculating, and start teaching maths". He estimates



Computer-based maths classes would make the subject more interesting

"Real maths isn't like the stuff taught in schools. Sure, there are percentages, but most of it is far more interesting"

that around 80 per cent of maths lessons are devoted to issues that computers have made irrelevant. Currently, he is leading a global campaign to persuade governments to make the radical shift towards a computer-based maths education.

Students have long suspected that much of what they're taught is pointless. A computer-based education would replace it with far more useful skills, like breaking problems down, estimating answers and knowing which computer techniques to apply.

Inevitably Wolfram's vision isn't going unchallenged. Critics say it's vital to know the basics – which is true, but too often they're the basics of pointless techniques like factorising quadratics.

Wolfram stresses the benefits to business of teaching maths for the real world rather than for exams. This doubtless helps sell the idea to politicians, but computer-based maths is about far more than that.

By freeing students of so much drudgery, it can give them a genuine love of arguably the most powerful and creative of human endeavours. ■

ROBERT MATTHEWS is Visiting Reader in Science at Aston University, Birmingham

PSYCHOLOGY

Sleep sharpens memory recall



A good night's sleep could be the key to exam success

IT SEEMS THAT the saying is wrong: if you snooze you *don't* lose. It's been known for some time that sleeping can protect memories from being forgotten, but researchers at the University of Exeter have shown that it can also make them easier to recall. After a good night's sleep we are almost twice as likely to recall facts that we could not remember while still awake, they say.

The team taught made-up words to two groups of volunteers, one in the morning and one at night. Both groups were tested immediately to see what they could remember, and again after a 12-hour period. The night group slept during this time while the morning group did not. After sleeping, members of the night group were significantly

more likely than their daytime counterparts to recall words they couldn't initially remember.

"The post-sleep boost in memory accessibility may indicate that some memories are sharpened overnight," researcher Dr Nicolas Dumay says. "This supports the notion that, while asleep, we actively rehearse information flagged as important. More research is needed into the functional significance of this rehearsal and whether, for instance, it allows memories to be accessible in a wider range of contexts, hence making them more useful."

Dumay suspects that the effect is due to our brains replaying recently encoded memories, allowing the major events of the day to be re-experienced.

ZOOLOGY

Armour inspired by seahorses

THE SEAHORSE CLINGS to coral reefs and seaweed using its tail, which has a vertebral column surrounded by bony plates. This square structure is stronger, stiffer and more resilient than other animals' cylindrical tails, according to Oregon State University engineers. Since it can also bend and twist, the structure could be used for military armour or surgical robots that move around organs or bones in your body.



A cylindrical structure (top) has far less surface contact when gripping an object than a square-shaped seahorse-inspired version (bottom)

SPACE

Dark matter may not be as mysterious as we thought



This new model predicts that dark matter would be spread out in galaxies (right) rather than clumped together, as in traditional models (left)

IT MAKES UP 85 per cent of the matter in the Universe and without it our Galaxy would fly apart. But since its discovery some 80 years ago, scientists have been unable to figure out exactly what dark matter is.

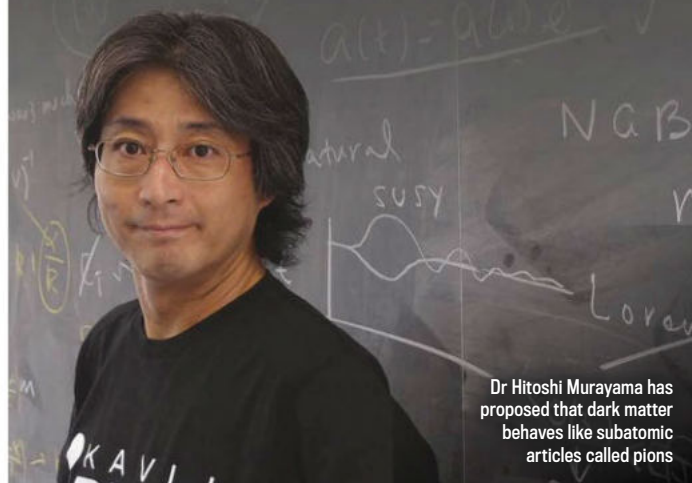
The only way that dark matter interacts with anything is via gravity. Because it doesn't interact with electromagnetic radiation, it appears to be invisible. It has widely been assumed that it is a completely new exotic form of matter unlike anything previously discovered. But now an international group of researchers has proposed a theory that dark matter behaves in a similar manner to pions. These are subatomic particles responsible for binding atomic nuclei together.

"We have seen this kind of particle before. It has the same properties - same type of mass, the same type of

interactions, in the same type of theory of strong interactions - that gave forth the ordinary pions," says researcher Dr Hitoshi Murayama. "It is incredibly exciting that we may finally understand why we came to exist."

The theory predicts dark matter is likely to interact with itself within galaxies and has so far yielded some promising results. "It can resolve outstanding discrepancies between data and computer simulations," explains researcher Dr Eric Kuflik. "The key differences in the properties between this new class of dark matter theories and previous ideas have profound implications on how dark matter can be discovered in upcoming experimental searches."

The next step will be testing the theory using experiments like the Large Hadron Collider.



Dr Hitoshi Murayama has proposed that dark matter behaves like subatomic particles called pions



HELEN CZERSKI

A CLEAR PROBLEM

How to stop your mirrors misting up

DON'T YOU THINK it's weird when you first notice something that's been staring you in the face for a long time? It happened to me a few weeks ago as I was tidying up in the bathroom. I was looking at the mirror and feeling vaguely grateful that it was sparkly and clean and didn't need any attention from me. And then it occurred to me that it doesn't ever seem to fog up. I dug around in my memory a bit. Mirrors definitely used to fog up. I'm pretty sure that my sister and I drove our mother potty at bathtime by scrawling in the fog on the large bathroom mirror in our family home. So I started to pay attention. Showers, baths, hot days, cool days... no fog. So out of sheer curiosity, I took the kettle in there just after it had boiled. Steam billowed past the glass, and a tiny misty patch appeared, and then quickly disappeared. Odd.

Fog forms from water vapour, which is the invisible evaporated water that's jostling about in the air with all the other gas molecules. If it happens to hit a cooler surface, it may stick. If there is a lot of water vapour in the air, more of those molecules will stick to the surface than can escape from it, and thousands of tiny droplets form. As light hits all those tiny, curved surfaces, it bounces around and the light leaves in many different directions. Instead of a clear reflection, we see a fuzzy optical mess. When the hot and humid air from a shower hits a cold mirror, you've got the perfect conditions for fog formation. And it's a nuisance in all sorts of other environments too – goggles, car mirrors, windscreens and camera lenses can all suffer.

My solution for this problem with swimming goggles is possibly not for everyone, but it works. I spit in them and rub the spit over the inner surface. This trick is also much beloved by scuba divers, who will spit in their masks before

entering the water. It works because the problem isn't the water itself – it's all those curved droplets that are scattering the light. They're there because the plastic in my goggles repels water slightly, so the water bunches up in separate droplets as it tries to touch as little of the surface as possible. A touch of saliva gives the water the right sort of surface to stick to the goggles and flatten out. When the droplets are so wide and so thin that they join together to form a continuous layer, the problem goes

“My solution for this problem with swimming goggles is possibly not for everyone, but it works. I spit in them”



away. The water still condenses, but the light travels straight through. You can also use baby shampoo or commercial anti-fog agents, and they all work in the same way, for a short while at least. But then they rub off. Therefore, the way to stop things fogging up isn't to repel the water. The trick is to embrace it.

You will probably be relieved to hear that I don't spit on my bathroom mirror. There is another potential solution: change the mirror. Coated glass that attracts pure water very strongly will give you the same effect as spitting on the glass. I think that's why my mirror doesn't steam up when I have a warm shower. To test my theory, I spent a while dripping water on to my mirror and the droplets collapsed almost instantly and then evaporated. Water is condensing, just like it always used to. But it's forming a thin puddle that covers the whole mirror and so it keeps itself invisible.

The technology that makes this possible is fantastic, but I am a little disappointed that I'm no longer able to write nonsense on the bathroom mirror! ■

DR HELEN CZERSKI is a physicist, oceanographer and BBC science presenter whose most recent series was *Super Senses*

BIOLOGY

Ageing process 'turned off' in worms

COULD A 'GENETIC switch' be the key to eternal youth? Researchers at Northwestern University in Illinois, USA have found that turning off specific genetic processes triggered in early adulthood effectively halted the ageing process in nematode worms. The same mechanism is also seen in other animals, including humans.

Further study could lead to therapies to provide humans with an improved cellular quality of life, and so delay diseases related to ageing, such as neurodegenerative diseases. "Wouldn't it be better for society if people could be healthy and productive for longer during their lifetime?" says researcher Richard I Morimoto. "I'm very interested in keeping the quality control systems optimal as long as we can, and now we have a target. Our findings suggest there should be a way to turn this switch back on, and protect our ageing cells by increasing their ability to resist stress."

In *Caenorhabditis elegans*, a type of nematode worm, the ageing process begins just eight hours after the animal reaches adulthood. Stem cells responsible for making eggs and sperm flick

a genetic switch that shuts off mechanisms which protect cells from stress. Once the stem cells have completed their job and produced eggs and sperm to create the next generation of animals, they send a signal

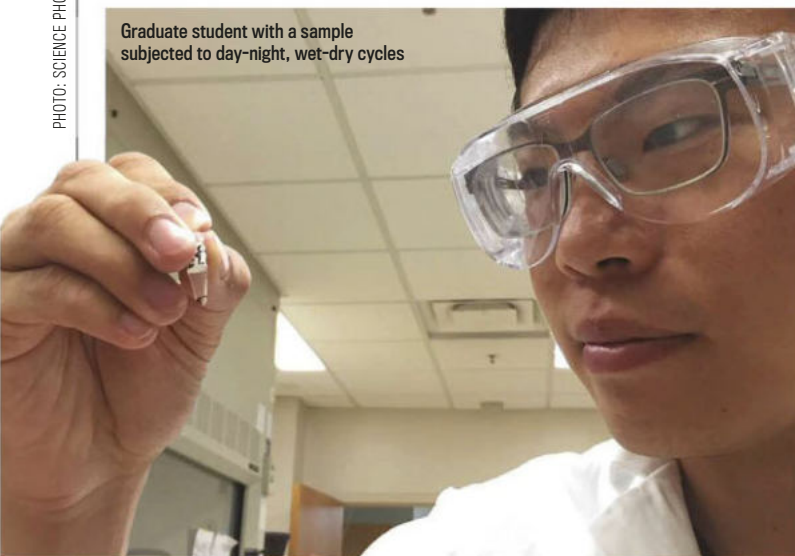
to cell tissues to turn off the protective mechanisms, starting the decline of the adult animal. "*C. elegans* has told us that ageing is not a continuum of various events, as many people thought it was," Morimoto says.



EVOLUTION

Did life on Earth begin in a puddle?

Graduate student with a sample subjected to day-night, wet-dry cycles



BEGINNINGS DON'T GET much humbler: a team at Georgia Institute of Technology believes life on Earth may have started in a puddle. They demonstrated that polypeptides – molecules essential for complex life – can be formed by mixing amino and hydroxyl acids and then subjecting them to cycles of alternating wet and dry conditions. The process could have taken place in a puddle that was drying out and then reforming with the next rain, they say.

The research supports the theory that life may have begun on dry land, where night-time cooling and dew formation

are followed by daytime heating and evaporation. "The simplicity of using hydration-dehydration cycles to drive the chemistry you need for life is appealing," says researcher Nicholas Hud. "It looks like dry land would have provided a very favourable environment for getting the chemistry needed for life started."

Just 20 of these day-night, wet-dry cycles were needed to form a complex mixture of polypeptides in the lab. Previous studies of meteorites have found that both amino acids and hydroxyl acids are likely to have existed on the early Earth.



STEPHEN BAXTER

GREEN SPACE

Will we find trees on other planets?

THE INTERNATIONAL SOCIETY of Arboriculture (ISA) holds its annual conference in Florida in August. It claims that "through research, technology, and education, the ISA promotes the professional practice of arboriculture and fosters a greater worldwide awareness of the benefits of trees." Those are worthy goals.

Trees are central to our sense of ourselves. We evolved from forest creatures, and today our world is still largely dominated by trees. Even after millennia of deforestation, there are 60 trees for every human being alive. No wonder trees show up so frequently in our stories, from Adam and Eve's Tree of Knowledge through the World Tree of Norse mythology, all the way to Groot, the living tree in *Guardians Of The Galaxy*.

Nowadays, human activity is impacting the trees. The greatest of our modern trees are sadly under particular threat. The sequoias of North America flourish in mountain ranges that trap moisture coming off the ocean. The trees were once widespread throughout the Rockies, but are now confined to a strip of the Pacific coast.

In the 1990s, intrepid biologists discovered that sequoias support a unique treetop ecology. Leaves falling from the sequoias often don't reach the ground, but become trapped in branches or trunk crevices, where they form a rich mulch. This supports the growth of plants and fungi, which in turn are fed on by insects, amphibians, reptiles and birds. Some of these species, such as clouded salamanders, are unique to the great trees; these amphibians have no lungs but breathe the moist, foggy air through their skin.

If trees dominated our past and our present, they will feature in our future. Biologists define a 'tree' by its form: a woody plant with secondary branches supported clear of the ground on a single main stem, or 'trunk'. And trees are a classic example of convergent evolution, in which radically different species adopt similar forms in response to similar environmental challenges. Most trees today are fruit-bearing (angiosperms) or coniferous, but the earliest trees on Earth were tree ferns, horsetails and club mosses, which grew in the Carboniferous forests of some 300 million years ago. Trees seem to evolve wherever a plant has to grow tall to compete for the light, while staying rooted in the ground for nutrients.

"Many mythologies imagine trees as sentient, a tradition reflected in Groot, and the Ents in *The Lord Of The Rings*"

Explorers could find sentient trees on distant worlds



So, if we found life on an alien world, it would be no great surprise to find something like trees. Of course, they might differ in detail, depending on local conditions. The tallest known tree on Earth is a sequoia in northern California, soaring to a height of 116m. But if gravity were weaker, trees could grow even taller. In Mars's gravity, which is one-third of Earth's, a tree might grow nearly to 500m.

Is there more to a tree than strength and beauty? Many mythologies imagine trees as sentient, a tradition reflected in Groot, and the Ents of JRR Tolkien's *The Lord Of The Rings*. These ideas received a boost in 1992 when researchers detected electrical signals, as opposed to chemical signals, being transmitted within the body of a tomato plant. In 2005, a Society For Plant Neurobiology was formed to foster these hypotheses.

But these aren't new ideas. "It is hardly an exaggeration to say that the tip of the radicle [a plant's primary root]... acts like the brain of the lower animals," wrote Charles Darwin himself in 1880. Perhaps our view of trees in the future will be much more sophisticated... ■

STEPHEN BAXTER is a science fiction writer who has written over 40 books. His latest is *Ultima*, published by Orion

Performance without compromise



Vanquish HAF III

- Intel® Core™ i5-4590
- ASUS® H81-Gamer
- 8GB HyperX FURY RAM
- 2GB NVIDIA® GeForce® GTX 960
- 120GB Kingston SSD
- 1TB Hard Drive
- Windows 8.1
- 3 Year Standard Warranty

THIS SPEC FROM **£749***



Apollo 703

- Overclocked Intel® Core™ i5-4690k
- ASUS® Z97-E
- 8GB HyperX FURY RAM
- 2GB NVIDIA® GeForce® GTX 960
- 250GB Samsung EVO SSD
- 1TB Hard Drive
- Windows 8.1
- 3 Year Standard Warranty

THIS SPEC FROM **£799***



Minerva

- Intel® Core™ i5-4690K
- ASUS® ROG MAXIMUS VII RANGER
- 16GB HyperX FURY RAM
- 4GB NVIDIA® GeForce® GTX 970
- 120GB Kingston HyperX 3K SSD
- 2TB Hard Drive
- Windows 8.1
- 3 Years Warranty

THIS SPEC FROM **£999***



Ultimate Ti

- Intel® Core™ i7-5930K
- ASUS® Rampage V Extreme
- 32GB HyperX PREDATOR RAM
- 6GB NVIDIA® GeForce™ GTX980Ti
- 6GB NVIDIA® GeForce™ GTX980Ti
- 240GB HyperX SAVAGE SSD
- 1TB Western Digital Black Hard Drive
- Windows 8.1
- 3 Years Warranty

THIS SPEC FROM **£2,999***

Optimus Nebula

- Intel® Core™ i7-4720HQ
- 15.6" Matte Full HD IPS LED
- 8GB HyperX IMPACT RAM
- 2GB NVIDIA® GeForce® GTX 960M
- 120GB Kingston HyperX 3K SSD
- 1TB Hard Drive
- Windows 8.1
- 3 Year Standard Warranty

THIS SPEC FROM **£849***



Defiance 17

- Intel® Core™ i7-4720HQ
- 17.3" Matte Full HD LED Screen
- 16GB HyperX IMPACT RAM
- 4GB NVIDIA® GeForce® GTX 980M
- 240GB Kingston SSD
- 1TB Hard Drive
- Windows 8.1
- 3 Year Standard Warranty

THIS SPEC FROM **£1,349***

Order your system now with PC Specialist



/pcspecialist



@pcspecialist

Some features require Windows 8.1. Update available through Windows Store. Internet access required; fees may apply. Microsoft, and Windows are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

*Prices are including VAT and are correct at the time of printing, but subject to change.



Award winning custom PC & Laptop manufacturer

Unleash the gamer within you



Vulcan 440

- Overclocked Intel® Core™ i7-4790K
- ASUS® Maximus VII Ranger
- 16GB HyperX FURY RAM
- 4GB NVIDIA® GeForce® GTX 980
- 500GB Samsung EVO 850 SSD
- 2TB Hard Drive
- Windows 8.1
- 3 Year Standard Warranty

THIS SPEC
FROM

£1,499*

Quality builds at a low price
Always

GET A FURTHER £15 OFF WITH THIS EXCLUSIVE VOUCHER CODE:

BBF29

ORDER ONLINE NOW

0333 011 7000

www.pcspecialist.co.uk

FOCUS

SCIENCE AND TECHNOLOGY

Save when you Subscribe
To the digital edition



Available from



The science magazine for the inquisitive mind, *Focus* brings you all that's new and exciting in science and technology



Enjoy our Premium App experience now available from



Download on the
App Store



GET IT ON
Google play



Available on
kindle fire

FOCUS

SCIENCE AND TECHNOLOGY

39 IDEAS

ABOUT TO CHANGE OUR WORLD



**FROM FLOATING FARMS TO VIRTUAL THERAPY,
WE BRING YOU THE INCREDIBLE INNOVATIONS
THAT WILL SHAPE OUR FUTURE**

"THE ONLY THING we can be sure of about the future is that it will be absolutely fantastic." These were the words of Arthur C Clarke, delivered during a 1964 episode of BBC *Horizon* broadcast from the World Fair.

He was right. Even as the planet's outlook becomes bleaker with the looming threat of climate change, humans search for smart solutions to the world's problems. Hundreds of great ideas come across our desks every week at *Focus*, but here we've handpicked the very best of them to paint a picture of your world might look like tomorrow.



YEARS AWAY



Your next car could be powered by a two-litre bottle of ammonia

01 THE HYDROGEN STATION

Toyota's hydrogen-powered car goes on sale this year. Mirai boasts zero emissions, unless you count harmless water vapour. But hydrogen cars are likely to remain expensive because, for safety reasons, hydrogen gas must be stored in heavy-duty, high-pressure tanks. So scientists at the UK's Science and Technology Facilities Council (STFC) have been busy developing a low-cost method of extracting hydrogen from ammonia. A two-litre bottle of ammonia would provide enough hydrogen for a typical family car, and could be stored at low pressure.



02 COFFEE POWER

The world's appetite for coffee has rocketed in recent years, with a coffee shop seemingly on every corner. But what do you do with all the waste produced during the coffee-making process? Entrepreneur Arthur Kay's big idea is to use his company, bio-bean, to turn 85 per cent of that waste into biofuels for heating buildings and powering transport. It has big potential – according to Kay, London's coffee industry alone creates over 200,000 tonnes of waste every year, the same amount produced in a year by the UK's big seven supermarkets.



WHAT PROBLEM NEEDS TO BE SOLVED MOST URGENTLY?

While microchips have become 10,000 times more powerful since the mid-1980s, battery capacity has increased by barely 10 per cent. Yet batteries are vital for everything from mobile tech to the solar economy. Anyone who comes up with cheap, stable, rechargeable battery with hefty capacity will make out like a bandit – and help save the planet.

ROBERT MATTHEWS
Focus science consultant



Waste products from coffee-making can be turned into biofuels

YEARS AWAY



03 COMPUTERS MADE OF WATER

Computers work by firing electrons around silicon circuits, but engineers at Stanford University have built a functioning computer that uses water droplets instead of electrons. It's hoped the idea could be used

to manipulate matter, perhaps leading to miniature labs capable of carrying out thousands of controlled reactions.

YEARS AWAY



04 SPACE DRONES

Unmanned probes are effectively space drones, but now NASA has challenged designers to develop a conventional drone to work inside a space station, navigating with no 'up' or 'down'. The winning design, ArachnoBeeA, would use cameras and

tiny beacons to manoeuvre its way around. How popular drones would be in such a confined space is a different question.

YEARS AWAY

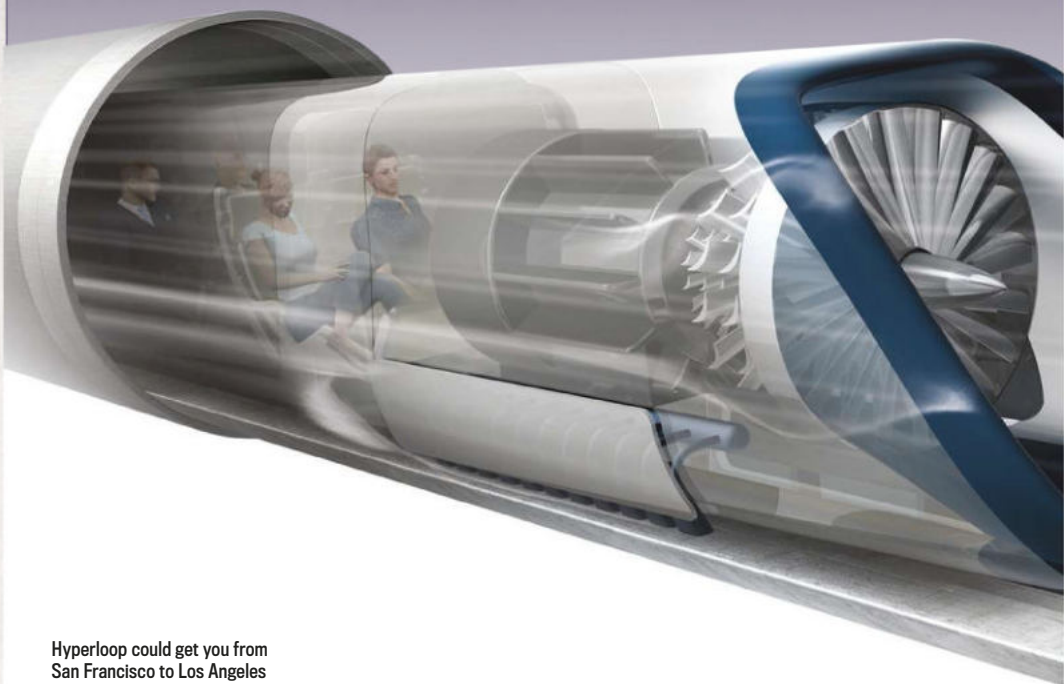


05 SUGAR-FUELLED PLANES

Air travel is bad news for the environment, and that's only likely to get worse if we continue to power planes with fossil fuels. However, a team at the Energy Biosciences Institute in Berkeley, California has come up with a new way to create aviation fuel from sugarcane. The system takes waste from sugar factories – ethanol, acetone and

butanol – and converts it into jet fuel. The research is being funded by BP, which is investing in similar work for fuelling our cars.

YEARS AWAY



Hyperloop could get you from San Francisco to Los Angeles in 35 minutes, compared to 7.5 hours by train

06 760MPH TRAINS

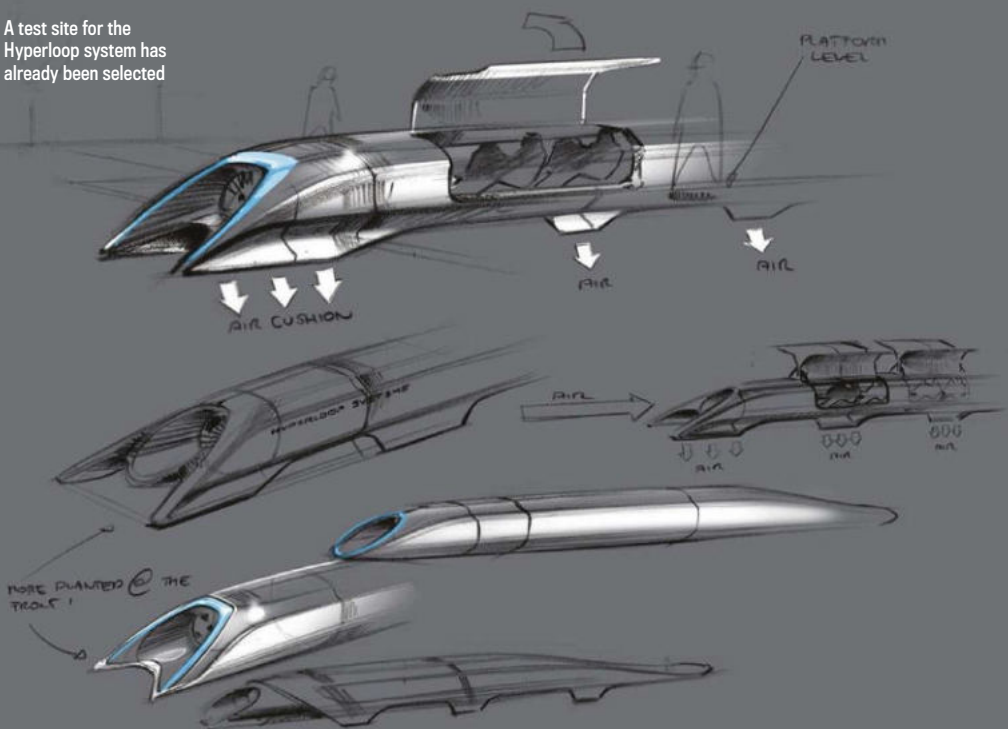
We all hate commuting. Imagine, instead, your train carriage hurtling down a tunnel at the same speed as a commercial jet airliner. That's the dream of PayPal, Tesla and SpaceX founder Elon Musk. His Hyperloop

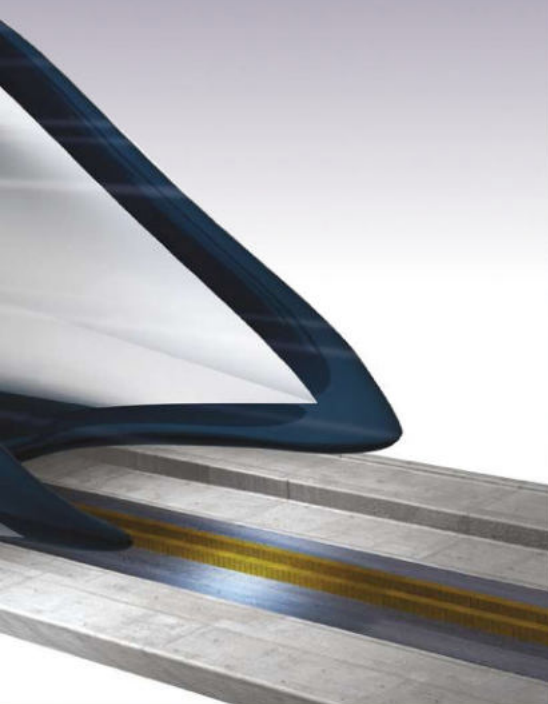
system would see 'train' passengers travel at up to 760mph through a vacuum tube, propelled by compressed air and induction motors. A site has been chosen with the goal of starting test runs in two years. Once built, the loop will ferry passengers between San Francisco and LA.

YEARS AWAY

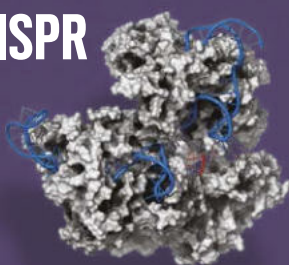


A test site for the Hyperloop system has already been selected





07 CRISPR



The idea of 'designer babies' has attracted a lot of negative attention, but gene-editing technology is undoubtedly a big step forward. A technique called Crispr (Clustered, Regularly Interspaced, Short Palindromic Repeat) targets unhealthy strands of DNA within a mutated immune cell and replaces them with healthy ones. Scientists hope that, once reintroduced to the body, the cell will be able to better fight off infection and disease.

The work done on T-cells (the immune cells responsible for battling pathogens) could be used in a whole new field of medicine: the technique has applications for the treatment of viruses, cancer and even HIV. There are already several companies in the medical arena that are putting modified T-cells back into patients, so the new technique has the potential to move forward very quickly.



08 THE AI SCIENTIST

Cut off a flatworm's head, and it'll grow a new one. Cut it in half, and you'll have two new worms. Fire some radiation at it, and it'll repair itself. Scientists have wanted to work out the mechanisms involved for some time, but the secret has eluded them. Enter an AI coded at Tufts University, Massachusetts. By analysing and simulating countless scenarios, the computer was able to solve the mystery of the flatworm's regeneration in just 42 hours. In the end it produced a comprehensive model of how the flatworm's genes allow it to regenerate.

Although humans still need to feed the AI with information, the machine in this experiment was able to create a new, abstract theory independently - a huge step towards the development of a

conscious computer, and potentially a landmark step in the way we carry out research.



09 SPACE BALLOON

If you want to take a trip into space, your quickest bet might be to take a balloon. The company World View Enterprises wants to send tourists into the stratosphere, 32km above Earth, on hot air balloons. Technically passengers won't reach 'space' (which is defined as 100km above sea level), but this altitude is high enough to witness the curvature of the Earth, just as Felix Baumgartner did on his space jump. The balloon flew its first successful test

flight in June, and the company will start selling tickets in 2016 - at the bargain price of just £75,000 per person!



WHAT NEW GADGET ARE YOU MOST EXCITED ABOUT?



“ Virtual reality. I demonstrated it on *Tomorrow's World* in the 1980s when it was in its absolute infancy, so it's extraordinary to see the way it's now being used : gaming, scientific visualisation, education, fashion, healthcare. The technology is becoming more and more affordable and much more accessible, so it will be fascinating to see what happens over the next five years. ”

MAGGIE PHILBIN
Tech reporter and former
Tomorrow's World presenter



10 BREATHALYSER CARS

The US National Highway Traffic Safety Administration has developed devices that can monitor alcohol levels by sniffing a driver's breath or scanning the blood in their fingertips via the steering wheel, immobilising the car if levels are too high. Drivers using the system could be offered lower insurance premiums.



11 A NEW APPROACH TO DEMENTIA

Around 850,000 people in the UK live with dementia. Patients have trouble remembering recent events, despite recalling things that happened decades ago. Having this pointed out can be upsetting, so the Butterfly Household Model of Care takes a different approach: it lets patients act out their memories, even providing props and clothes that remind them of their younger selves. Over 100 care homes have already adopted the model.



12 VIAGRA FOR WOMEN

Now approved by the US Food and Drug Administration, flibanserin looks set to become the first in a new class of drugs for improving female sexual desire. Though it's been dubbed 'the female Viagra', flibanserin works rather differently: Viagra works by boosting blood supply to the penis, while flibanserin acts on serotonin receptors in the brain. Its makers say it increases sexual satisfaction, but critics question the drug's safety and effectiveness.



13 CROWD-SOURCED ANTIBIOTICS

Swallowing seawater is part of surfing. But now the scientists behind a new initiative called Beach Bums want to swab the rectums of surfers, to see if this water contains the key to developing new antibiotics. They're searching for antibiotic resistant bacteria known as superbugs: by studying the samples from the surfers, they hope to learn more about these potentially dangerous organisms in the hope of producing new drugs to combat them. And this next generation of antibiotics could

also come from an unlikely source. Drugs From Dirt, a US citizen science project, is asking people to send in soil samples from their gardens. The DNA of microorganisms within the samples will then be sequenced to discover specific genes, and within them, proteins that could be used to create new antibiotics. Scientists hope to discover previously unknown biosynthetic systems that create antibiotic molecules, identify those molecules and use them to create new drugs. The project's already underway, so a whole new class of antibiotics could be dug up tomorrow!



The next generation of antibiotics could be lurking behind the petunias in your garden

WHAT SCIENTIFIC OR TECHNOLOGICAL ADVANCE WORRIES YOU THE MOST?



“Although I'm sure that drones can do lots of exciting and useful things, I think it would be a huge shame to fill the sky with them. Even now, we really don't appreciate the sky enough – it's the last great expanse of free and open space in our society. Drones are a fairly insidious technology – their numbers will grow slowly until they're everywhere. They're also going to reflect the huge, ongoing battle between security and privacy.”

DR HELEN CZERSKI
Experimental physicist and BBC presenter

14 INTERNET FOR EVERYONE

After Tesla and SpaceX, PayPal founder Elon Musk is turning his attention back to the internet: he's awaiting permission to send almost 4,000 small satellites into low-Earth orbit that would beam back a high-speed wireless signal to everyone on the planet.

And things are moving fast: Musk hopes to launch a series of test satellites in 2016, with a view to completing the project by 2020.

YEARS AWAY



15 SMART FOOD LABELS

UK homes throw away 30 to 50 per cent of what we buy from supermarkets, says a 2013 report by the Institution of Mechanical Engineers. The report claimed we're guided by 'use by' and 'best before' dates on food packaging, which are kept conservative because they are driven by shops' desire to avoid legal action. An invention called 'Bump Mark' could change all that. Originally developed for blind people, it's a label that starts out smooth to the touch but gets bumpy as food decays. And since it decays at the same rate as any protein-based food within, it's far more accurate than printed dates.

YEARS AWAY



16 PERSONALITIES FOR ROBOTS

Google has obtained a patent on robot personalities, reminiscent of the 'Genuine People Personalities' of robots in *The Hitchhiker's Guide To The Galaxy*. Owners could have a personality automatically chosen to match their needs, or select one based on a fictional character or even a loved one. Although the patent was announced suspiciously close to April 1, it does exist (US Patent 8,996,429), and with our natural tendency to anthropomorphism it seems a likely development.

YEARS AWAY



17 VIRAL HISTORY BLOOD TEST

Every time you're infected with a virus, your body dispatches antibodies to fight it, which remain in your bloodstream long after the virus has been defeated. Now, a device called VirScan is being trialled at Harvard Medical School that can analyse a single drop of blood and detect antibodies for 1,000 virus strains, telling doctors of any virus you've ever had. It could transform diagnosis, as doctors currently have to test for specific viruses.

YEARS AWAY



18 £3 PAIN-FREE TATTOO REMOVAL



Alec Falkenham is pioneering a new method of tattoo removal

Got a tattoo that you now regret? There may soon be a gentler, cheaper alternative to laser removal. PhD student Alec Falkenham in the US has worked out how to harness a property of your body's own immune system. He's developed a cream that delivers drugs to white blood cells called 'macrophages' (Greek for 'big eaters'), causing them to release the ink they took up in order to protect your skin during the tattooing process.

YEARS AWAY



19 SELF-DRIVING TRUCKS

We've almost got used to the idea of driverless cars before we've even seen one on the roads. The truth is, you might well see a lot more driverless trucks – after all, logistics make the world go round. They'll be cheaper to run than regular rigs, driving more smoothly and so using less fuel. Computers never get tired or need comfort breaks, so they'll run longer routes. And they could drive in convoys, nose-to-tail, to minimise wind resistance. Companies like Mercedes and Peloton are already exploring these possibilities, and if the promised gains materialise, freight companies could upgrade entire fleets overnight. On the downside, it could put drivers instantly out of work, and even staff at the truck stops set up to service them, but many companies have said the trucks will still need a human passenger to ensure their cargo is safe.

YEARS AWAY



20 VIRTUAL THERAPY

US soldiers in California have been putting on Oculus Rift virtual reality headsets as part of their PTSD therapy. The virtual experience takes the soldiers back to the battlefield from the safety of the sofa, helping them tackle their anxieties in a controlled space. A similar technique has been used to treat victims of sexual assault and motoring accidents. Meanwhile, a lab at the Pompeu Fabra University has managed to treat a form of partial paralysis using VR. The pilot study helped stroke patients regain movement using a special gaming system. Patients played a game where they picked up a ball, and the actions of their virtual limbs were tuned to the nerve signals in the paralysed side of their body. Even just a 10-minute session led to patients using their paralysed side more.

YEARS AWAY



Driverless trucks could soon be transporting goods around the country

WHAT IDEA CURRENTLY IN DEVELOPMENT HAS THE MOST POTENTIAL?

“A multipurpose handheld medical device that can plug into a mobile phone and carry out blood, urine and saliva tests would be a huge breakthrough. It would be able to detect conditions such as malaria, typhoid, anaemia and diabetes, potentially saving millions of lives in regions without easy access to medical facilities.”

PROF DANIELLE GEORGE

Radio frequency engineer and presenter of the 'How To Hack Your Home' Christmas lectures



21 AUGMENTED REALITY SURGERY

Brain surgery can often be a step in the dark for surgeons, because the networked nature of the brain means the scalpel is never far from damaging vital areas. The solution could lie in augmented reality. Canadian company Synaptive Medical is working on the concept of augmented reality surgery, where images of the operation are overlaid with visuals that map out structures within the brain. While a surgeon is operating, a robot magnifies the region, displaying what it sees on a video screen. Combining this view with complex, colour-coded images from MRI scanners, the robot gives the

surgeon a far more defined route into the area in which they intend to operate.

YEARS AWAY



Augmented reality can be used to create a kind of sat-nav for neurosurgeons

22 CARBON CAPTURE FORESTS

A simple way of removing CO₂ from the atmosphere is being pioneered by scientists at the University of Hohenheim, Germany. They've been carrying out trials of the jatropha plant, which absorbs and stores large amounts of CO₂. Jatropha grows in arid environments, and the scientists now have permission to 'carbon farm' 10,000 hectares of a coastal region in Saudi Arabia.

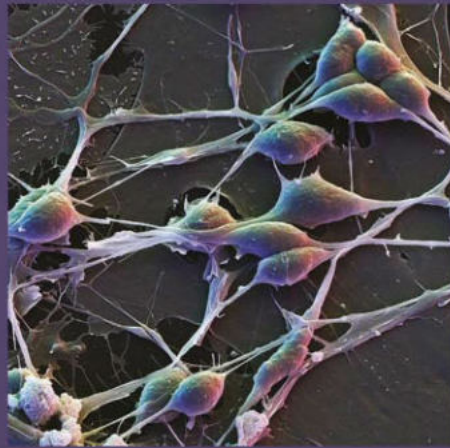
YEARS AWAY



23 SLEEP IN A PETRI DISH

Up to 30 per cent of us have trouble sleeping, but help may be at hand. A team at Washington State University has identified the smallest set of neurons in our brains responsible for sleeping, grown a tiny group of these cells in the lab and induced them to fall asleep and wake up. Their work could help to unravel the science of sleep disorders.

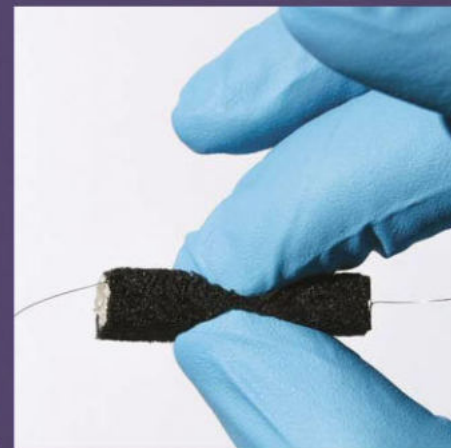
YEARS AWAY



24 SHAPE-SHIFTING BATTERIES

Experimental batteries are under test based on a very light foam made from tree cellulose, which could be shaped into almost any form. The foam is coated with thin layers of copper hexacyanoferrate and carbon nanotubes to form the battery's electrodes. The approach could produce batteries that are flexible, malleable and have a high capacity.

YEARS AWAY





Sergio Canavero hopes to attempt a human 'head transplant' soon



25 HUMAN HEAD TRANSPLANTS

An Italian neurosurgeon intends to attempt the first human head transplant by 2016. In reality it's a body rather than a head transplant, replacing a failing frame with a new one. In fiction, such a move is the stuff of horror stories, but Sergio Canavero believes it is possible. No successful animal transplants with long-term survival have yet been made because of the difficulty of connecting up the spinal cord, but Canavero has suggested improvements in the process

using a special blade and polyethylene glycol, a polymer used in medicine as well as in everything from skin cream to the conservation of the Mary Rose. This compound can help start growth in spinal cord nerves, though there would still be many problems to overcome to ensure the brain stays alive and in control of the body.

Other experts say Canavero is wildly optimistic. They point out that there would have to be far more animal experimentation, which many consider unethical, before any human trial. But we can at least expect improved ability to repair damaged spinal cords over the next decade, restoring body function to some spinal injury patients.

26 HOLIDAY BY AIRSHIP

If you've heard of the Hindenburg disaster, you'll probably question the advisability of firing up massive passenger balloons filled with flammable gas. But modern airships are filled with helium rather than hydrogen, and can fly for thousands of kilometres while burning less fuel than an aeroplane. The UK-built Airlander 10 is actually a hybrid, using helium to provide 60 per cent of its lift, while the rest is provided by its wide, wing-like hull. The first airships have been given government grants to investigate whether they could

replace long-haul freight trucks and cargo ships, but the company also has more ambitious plans for tourism.



27 WATER FROM A BOX

750 million people worldwide have no access to safe drinking water. To solve this problem, researchers at the University of the West of England are working with Portsmouth Aviation engineers to manufacture shipping container-sized boxes

that can be plugged into contaminated water sources to produce 18,000 litres of clean water an hour.



A device that transforms contaminated water into clean water would change lives



Could the once-derided airship be about to make a comeback?

28 SNIFFING OUT DISEASE

One day, you might go to the doctor and get an on-the-spot diagnosis for your stomach bug simply by breathing into a machine. This electronic nose would 'sniff out' disease molecules on your breath - no need for a stool sample. Such breathalyser-like devices already exist, and are in development for tuberculosis.

YEARS AWAY



29 DROWN FOREST FIRES IN SOUND

Forest fires could one day be dealt with by drones that would direct loud noises at the trees below. Since sound is made up of pressure waves, it can be used to disrupt the air surrounding a fire, essentially cutting off the supply of oxygen to the fuel. At the right frequency, the fire simply dies out, as researchers at George Mason University in Virginia recently demonstrated with their sonic extinguisher. Apparently, bass frequencies work best.

YEARS AWAY

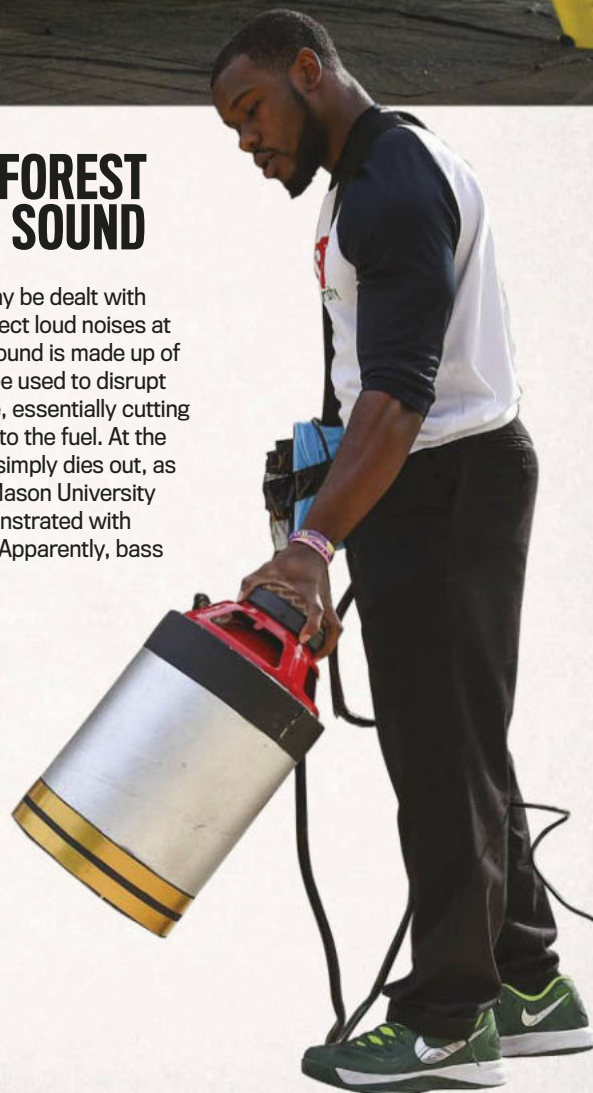


PHOTO: MASSIMO BREGA, GETTY X2, DARREN REYNOLDS/UWE



30 FLOATING FARMS

Floating farms seem like an idea whose time has come. The UN predicts there will be two billion more people in the world by 2050, creating a demand for 70 per cent more food. By that time, 80 per cent of us will be living in cities, and most food we eat in urban areas is brought in. So farms moored on the sea or inland lakes close to cities would certainly reduce food miles. But how would they work? A new design by architect Javier Ponce of Forward Thinking Architecture shows a 24m-tall, three-tiered structure with solar panels on top to provide energy. The middle tier grows a variety of veg over an area of 51,000m², using not soil but nutrients in liquid. These nutrients and plant matter would drop into the bottom layer to feed fish, which are farmed in an enclosed space. A single Smart Floating Farm measuring 350 x 200m would produce an estimated 8.1 tonnes of vegetables and 1.7 tonnes of fish a year. The units are designed to bolt together,

which is handy since we'll need a lot of them: Dubai, for instance, imports 11,000 tonnes of fruit and veg every day.

YEARS AWAY



31 THE BLACKEST EVER PAINT

Solar energy is our best option for filling in the void left by depleting fossil fuels, and a new kind of solar energy plant is popping up across Spain and the Middle East. Concentrated solar power (CSP) uses mirrors or lenses spread over a large area to focus sunlight on onto a much smaller, central collecting area. The problem with some early CSP technology, however, is that the collector materials waste a lot of energy because they can't absorb it all. So how do you make a really energy-absorbent material? Make it really, really black! That's exactly what scientists at the University of California San Diego are doing: their new nanoparticle-based coating mops up 90 per cent of the energy that hits it.

YEARS AWAY



Testing new ultra-absorbent coatings in the lab

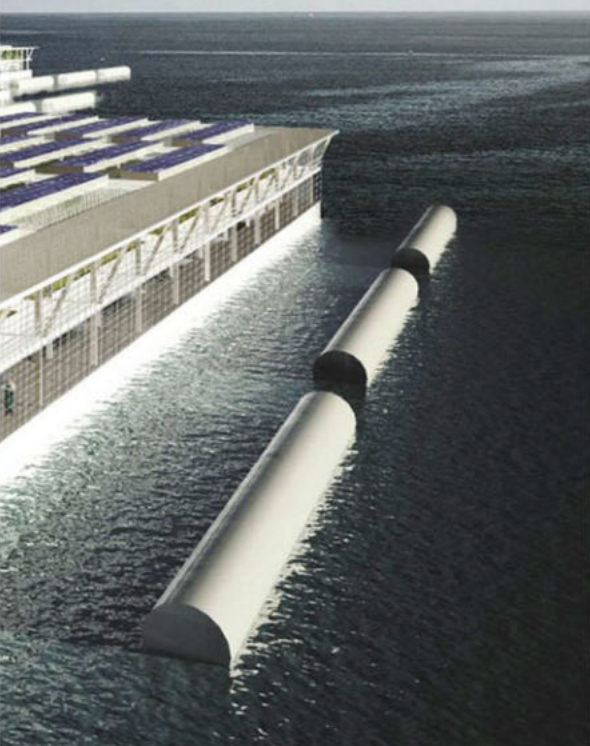


32 A PAINKILLER MADE OF LIGHT

About 10 per cent of the world's population suffers from long-lasting pain. Whether it's back pain or a condition like arthritis, it can have a devastating impact, making sleeping, working and even the simplest daily activities complete agony. While the mainstay of treatment for chronic pain is opioid drugs like morphine, these drugs are addictive and have unpleasant side effects due to the body's receptors for them being located in areas besides those where the pain occurs.

Researchers at Washington University in St Louis, Missouri are searching for better ways to target chronic pain. Michael Bruchas's team has fused light-sensitive proteins with opioid receptors to create hybrid molecules that can be activated - in mice - with light from LED implants. For now, he says, it's more about exploring how pain signalling actually works. In the future, however, gene therapy approaches could be used to produce light-activated proteins

Floating farms located close to big cities could reduce food miles considerably



33 COMPUTERS THAT SEE YOUR PAIN

Children can't always explain how much pain they're in, so health workers use pain scales, such as a series of faces showing different expressions. Now, US researchers have developed computer software that rates pain levels from facial

expressions. In tests, computers were as good as nurses and parents at rating pain severity.



34 YOUR BRAINPRINT AS A PASSWORD

Could your brainwaves function as your computer password? A team at Binghamton University, New York, looked at the way volunteers' brain signals changed as they read a list of acronyms. Each person reacted differently enough for the system to predict

who was reading the list with 94 per cent accuracy. In future, a honed version of this idea could verify who is sitting at a PC.



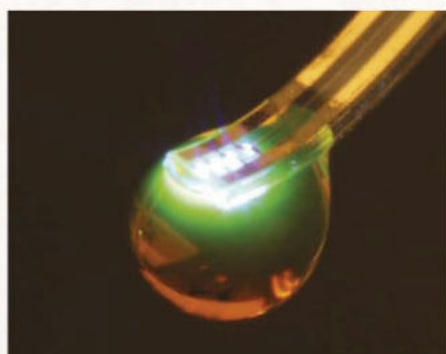
Brainwaves could be utilised as your computer passwords

in specific nerve cells and direct their interactions with pain networks using light.

Alternatively, the implants could switch on light-sensitive drugs that would only be activated in the painful region. "So you could have this implant in your spinal column and then we'd be able to shut off the pain response locally there," says Bruchas.



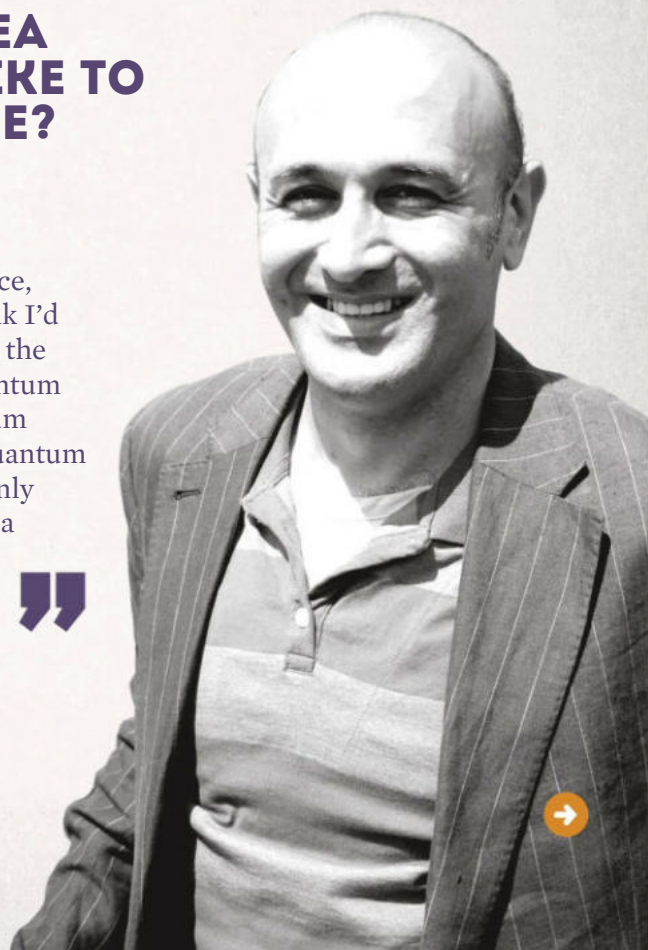
Pain receptors could be genetically modified to respond to light



WHAT FILM IDEA WOULD YOU LIKE TO SEE COME TRUE?

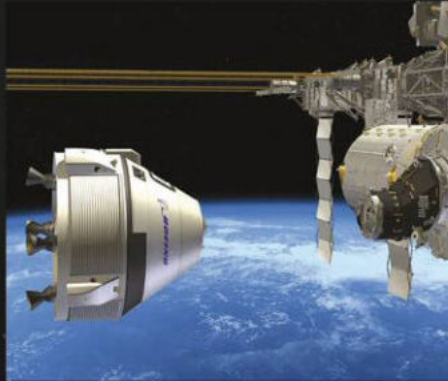
“ If we're talking about technologies that rely on current solid science, time machines are out. I think I'd like any gadget that relies on the weirdness and power of quantum physics, so a working quantum computer or, better still, a quantum teleporter. Although I certainly wouldn't turn my nose up at a traversable Lorentzian wormhole, like we saw in the film *Interstellar*. ”

PROF JIM AL-KHALILI
Physics professor and BBC presenter



35 NASA BUYING SPACE SHIPS

Despite the explosion of the unmanned SpaceX rocket heading for the International Space Station in June, commercial flights are expected to play an increasingly significant role in the US space programme. NASA has commissioned Boeing to provide a manned flight in 2017, and expects also to use SpaceX. US space technology has always been built commercially – the Space Shuttle, for instance, was constructed by Rockwell International – but off-the-shelf launches by commercial enterprises seem set to become increasingly common.



The future of spaceflight is probably private

YEARS AWAY

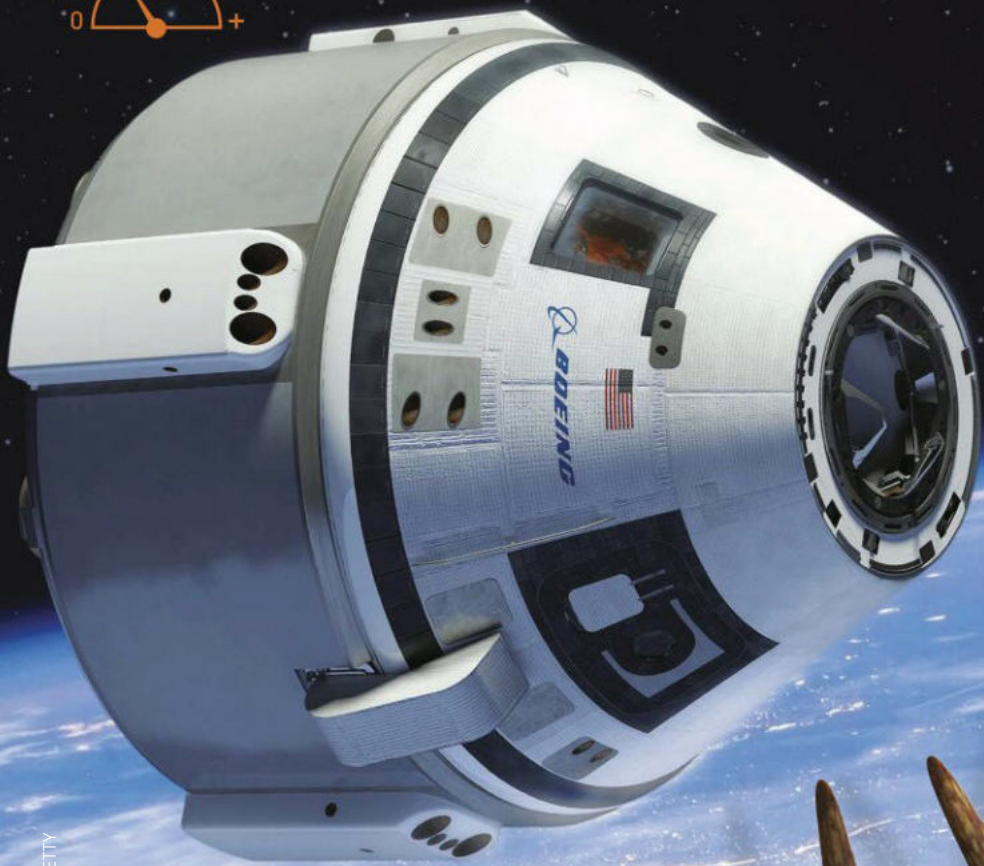


PHOTO: NASA/BOEING X2, CORBIS, GETTY

36 THE FOUR-DAY WORKING WEEK

It turns out working less might mean more work gets done. A raft of studies have shown that with less time to work, less time is wasted – there's less absenteeism and, in most cases, greater productivity. A more compact working week has also been shown to encourage employees to stay with companies for longer, and works as a recruitment tool. A shorter working week could even reduce global carbon emissions, with fewer commuters clogging the roads on certain days. In 2000, a 35-hour working week was introduced in

France, and despite later revisions, our neighbours across the Channel still work far fewer hours than we do.

YEARS AWAY



37 PLEISTOCENE PARK

Russian scientist Sergey Zimov hopes to recreate a 12,000-year-old environment in a wildlife park for herbivores like wild horse and bison, with extinct megafauna like mammoths replaced by modern hybrids. Zimov will study the impact of the animals on environment and climate.





A lump of aerogel balanced on a flower, demonstrating just how light the material is

38 EXTRA SENSES

Humans have long looked for ways to help those deprived of a sense – Braille for the blind, sign language for the deaf. And now, neuroscientist David Eagleman has designed a vest that converts sounds into vibrations which the wearer can feel. Voices and other ambient sounds are picked up by the wearer's smartphone, which then uses an app to transfer the sounds to the vest via Bluetooth.

YEARS AWAY



39 NEAR-PERFECT INSULATION

There are two things the majority of people in the Western world own: a refrigerator and a mobile phone. And aerogels could revolutionise the manufacture of both.

An aerogel is a material that's full of tiny holes. Made by extracting all the liquid from a gel, it can be up to 95 per cent pores. Those pores are so small – between 20 and 50 nanometres – that gas molecules can't squeeze through them. As a result, aerogels can't transport heat, making for a material with incredible insulating properties.

Although the first silicon aerogels were developed decades ago, early versions were so brittle you could crush them between your fingers. But as Mary Ann Meador of the NASA Glenn Research Center in Cleveland, Ohio explains, a new breed of polymer-based aerogels is now being developed that are far stronger,

and that could be useful in everything from re-entry materials for spacecraft to common kitchen appliances.

"If you want a higher efficiency refrigerator, one way to do it would be to increase the amount of insulation you use, but that would make the refrigerator bigger or the inside smaller," says Meador. "Replacing conventional insulation with an aerogel will allow you to put maybe five times as much insulation in the same gap."

The unusual electrical properties of aerogels also make them suitable as lightweight antennae for mobile phones, satellites and aircraft. ■

YEARS AWAY





HIGH STREET GENETIC TESTS

Dr Michael Mosley reports



You can buy a do-it-yourself DNA test kit for just £125. Can they really offer us a useful peek at our future health problems, or are they a waste of time and money?

THE FIRST GENETICS test I ever did was while I was making a programme for *Horizon* called *The Truth About Exercise* back in 2012. The premise was that I would test the claim that you can get most of the benefits of exercise from just three minutes a week of high intensity training (HIT).

My guide into the world of HIT was Prof Jamie Timmons, who then worked at Birmingham University as an expert in ageing biology. Despite my scepticism, Timmons assured me that if I did just a few minutes of HIT a week for four weeks, I could expect to see significant changes in a couple of important health indices.

The first improvement I could expect to see was in my insulin sensitivity. Insulin removes sugar from the blood and it controls fat. When it becomes ineffective, you become diabetic. The second improvement I was likely to see would be in my aerobic fitness (VO_2 max). Aerobic fitness is a measure of how good your heart and lungs are at getting oxygen into your body, and is an excellent predictor of future health. It is usually measured in an exercise laboratory, though there are other ways of assessing it.

Before I did his HIT programme, Timmons gave me a couple of test tubes to spit into. I knew it was for some form of genetic test, but the BBC producer asked Timmons not to tell me any more than that. So I went off and dutifully did my four weeks of HIT, and then went back to the lab to be tested again.

The results were mixed. My insulin sensitivity improved by a remarkable 24 per cent, which was extremely satisfying, but my aerobic fitness did not improve at all. Timmons was not surprised. It turns out that the genetic test I had done suggested that I would be what's called a 'non-responder' when it comes to aerobic fitness. However much exercise I had done, and in whatever form, my VO_2 max would not have improved. My dreams of winning Olympic glory ended there and then.

IN YOUR GENES

It's been known for some time that people respond to exercise regimes in very different ways. Scientists had previously assumed that this is because of differing levels of compliance: high compliers get fitter and poor compliers don't. However, it is now clear that genetics plays a big part.

When Timmons and his collaborators looked at studies they found that 15 per cent of people see big improvements in VO_2 max when put through a supervised exercise regime, so-called 'super-responders'. On the other hand, 20 per cent show no real improvement at all – 'non-responders' such as me. They investigated the reasons for these variations and discovered that much of the difference could be traced to a small number of genes. So what's the point of doing a test like this?

"If you don't normally do much exercise and you take the test and find out that you are a high-responder, then hopefully you will be motivated to



➔ get up and get going,” Timmons said. “If you are a non-responder, then you know you need to adapt your workout routine to make it more effective, perhaps have longer periods of recovery.”

One issue with all genetic tests is reliability. How do you know that the answers are valid? I trust Timmons because his research is based on good science, but there are plenty of other genetic tests that are not. A friend of mine, Peta Bee, who writes about exercise for *The Times*, decided to give it a go. Unlike me, she is very keen on exercise and likes nothing better than a long run. She sent a swab off to Timmons and the answer she got back was the one she was expecting: she was a high aerobic responder, best suited to endurance-type activities.

But when she sent a swab off to another company, they told her that her endurance potential was low and she was much better suited to power and strength activities such as sprinting and weight training. They also recommended netball and

“I was particularly interested in my risk of getting Alzheimer's, as I suspect my father was becoming a little bit demented towards the end of his life”

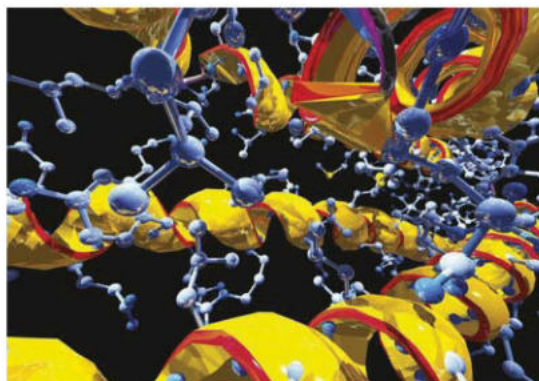
football, neither of which has she ever shown the remotest enthusiasm or aptitude for. Timmons is not surprised because, as he put it, “lots of companies are offering genetic tests for sporting performance and personalised macronutrition, but most are completely implausible.”

Wind forward a few years and *Horizon* once more asked me to donate spit, this time to try out a genetic test provided by 23andMe. The Californian company is named after the 23 pairs of chromosomes in a normal human cell. The US Food and Drug Administration (FDA) decided a few years ago that they and other similar companies were selling ‘medical devices’ and told them to stop marketing the health side of their product. So they stopped advertising in the US, but continued selling.

23andMe certainly make genetic testing very simple. I logged on and paid £125. You can also buy the kit at a high street chemist. A short while later they sent me a package with instructions.



23andMe places DNA on a unique genotyping chip to capture information about ancestry and health



One version of ApoE is linked to a higher risk of Alzheimer's disease

I swabbed my mouth and sent it back. A few weeks later the results pinged up on my computer. The website is rather impressive. They give you lots of data about your genome, along with references to the studies that form the basis of their claims. They also include a star marking relating to how reliable the data is likely to be.

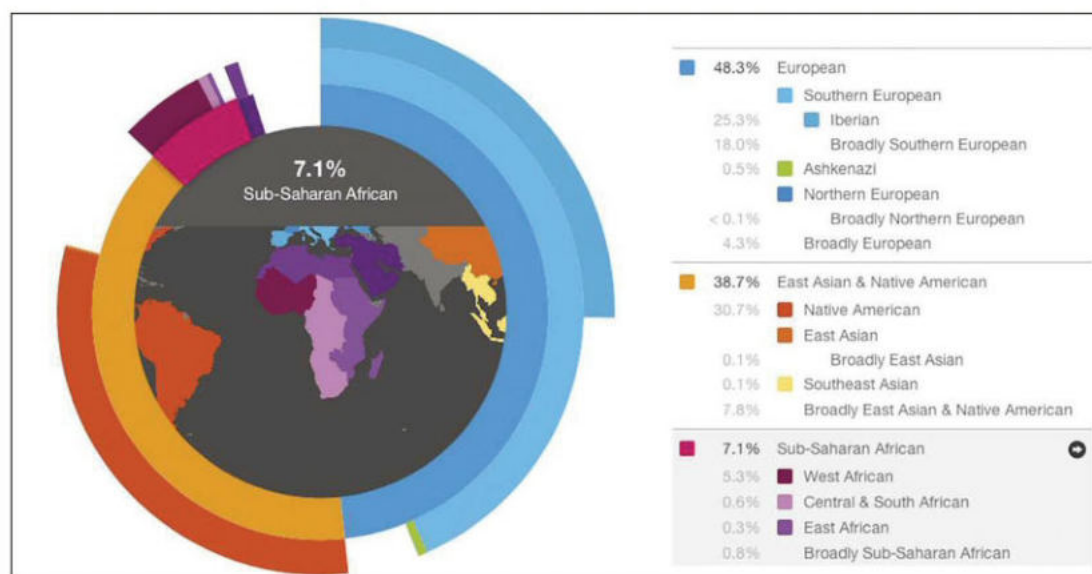
FAMILY TREE

I started by looking at my ancestry, and discovered that I am 98 per cent European, with just a hint of the Middle East and North Africa – 1 per cent. I am also 1 per cent Asian. This fits in with what I know about my family tree. I had a quick look at inherited conditions and was relieved to see that I am not a carrier of any of the genetic mutations they list, including cystic fibrosis.

I then opened the section on traits. These include things like alcohol flush reaction. Some people,



23andMe offers clear and detailed ancestry reports



particularly those from South East Asia, flush when they drink alcohol. This is largely down to their reduced ability to metabolise alcohol, which in turn is down to the effectiveness of genes that produce the enzyme alcohol dehydrogenase. I don't flush. They were very confident I would have straighter hair than average, which is right, but said it was only 28 per cent likely that it would be blonde. I'm not. They told me I'd be tolerant to lactose, which I am, but said my muscle performance suggested I would be a sprinter, which is not true.

I moved on to genetic risk factors, which is undoubtedly the most controversial part of the test. I was particularly interested in my risk of getting Alzheimer's, as I suspect my father was becoming a little bit demented towards the end of his life. There is one gene in particular, ApoE, that is strongly implicated in late-onset Alzheimer's (after the age of 65). No-one knows quite how it works, but ApoE influences the build-up of a protein named amyloid beta in the brain. This protein is found in higher levels in people with Alzheimer's.



23andMe's £125 test kit

In his characteristic guinea pig fashion, Michael Mosley once again volunteers for medical tests



“The advice you’re going to get from your doctor is going to be the same regardless of genetics: don’t eat so much, don’t smoke, exercise more”

Dr Ewan Birney, European Bioinformatics Institute

➔ The 23andMe test covers three ApoE variants: e2, e3 and e4. It is the e4 variant of the gene that you want to avoid.

According to the website, if you are of European ancestry then one copy of e4 means you have an 18 to 35 per cent of developing Alzheimer’s disease by the age of 85. These numbers rise to 51 to 68 per cent if you have two copies of the e4 variant. So, did I really want to know? After a brief pause I decided the answer was ‘yes’, so I downloaded my results. I was relieved to get the following message: “Michael Mosley has two copies of the ApoE e3 variant, this variant is not associated with a high risk of developing Alzheimer’s disease.”

I don’t know how I would have responded if the answer had been ‘higher risk’. According to the website, having the e4 variant does not mean that a person will definitely develop Alzheimer’s. But I’m not sure how reassuring that would be.

I went to visit geneticist Dr Ewan Birney, Director of the European Bioinformatics Institute, to see what he thinks about these sort of tests.

“I’m not a fan,” he said. “There is a fun side to it, you can use it to trace your ancestry, but I wouldn’t recommend it as a way of monitoring my health or

Dr Ewan Birney thinks that genetic tests could lead to people becoming unnecessarily worried about their future health

23andMe scientists at work in the lab



your health. There’s a risk you might get worried inappropriately, that you will become obsessed about a particular diagnosis that may or may not be right. So this is best handled when you’re meeting a clinician who has experience of all of these scenarios to give you good advice.”

Birney said the tests are quite reliable when it comes to conditions that are affected by a single gene mutation, but not for many common disorders.

“For most common diseases, things like heart disease and Type 2 diabetes, your doctor will know a lot more just by doing some simple tests and finding out about your family history,” he said. “How heavy you are, whether you smoke, whether your parents had heart disease – these are more predictive than a spit test. And the advice you’re going to get from your doctor is going to be the same regardless of your genetics, which is don’t eat so much, don’t smoke, exercise more.”

HEALTH MONITOR

Birney thinks there is a place for personalised genetic testing, but within the healthcare system. He gave me the example of warfarin. Warfarin is an anticoagulant that’s given to patients with an irregular heartbeat or deep vein thrombosis. The problem is that people metabolise warfarin at very different rates, so it is hard to know what dose to put a patient on. Doctors normally start on a low dose, test your clotting time, then increase it gradually. A genetic test that can reliably predict how quickly you will metabolise warfarin would mean you could be started on the right dose quickly, saving lives and a huge amount of testing.

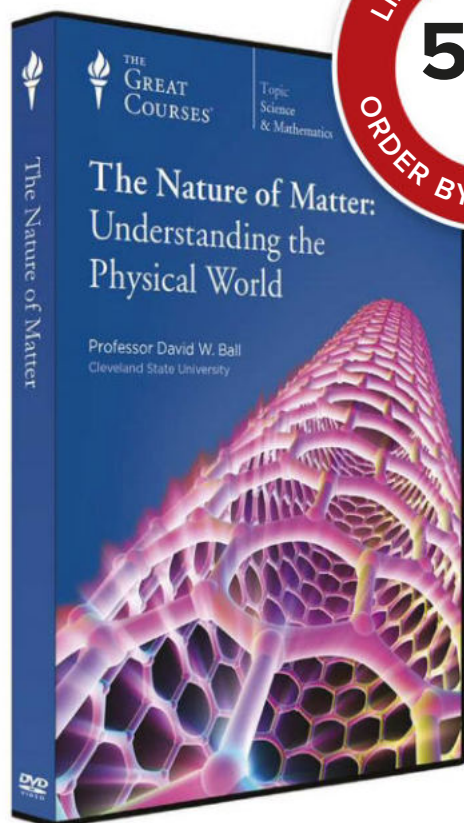
So is this the future, I asked? “No,” he said. “It’s not the future. It’s now.” ■

DR MICHAEL MOSLEY is a BBC presenter of *Trust Me, I’m A Doctor* and the author of *The Fast Diet* and *Fast Exercise*

DISCOVER MORE!



Dr Michael Mosley will be presenting a *Horizon* episode about DNA testing on 12 August – catch it on iPlayer



Discover How Matter Makes the Universe

Matter is the raw material of the universe. Now, you can discover how the immense variety of matter—stars, mountains, plants, people—is created by a limited number of chemical elements that combine in simple, well-defined ways.

The Nature of Matter: Understanding the Physical World deciphers the mystery of matter in 24 engaging and enlightening half-hour lectures that are geared towards anyone with a curious mind. Your guide is Professor David W. Ball of Cleveland State University, a noted researcher, textbook author, and award-winning teacher, who has a gift for making scientific subjects accessible and engaging. You investigate and appreciate such miracles of everyday life as the bounce of a rubber ball or water's astonishing power to dissolve and examine science's ability to harness matter with such inventions as semiconductor circuits, new fabrics, and powerful adhesives.

Offer expires 19/09/15

THEGREATCOURSES.CO.UK/8FS

0800 298 9796

The Nature of Matter: Understanding the Physical World

Taught by Professor David W. Ball
CLEVELAND STATE UNIVERSITY

LECTURE TITLES

1. Matter, Energy, and Entropy
2. The Nature of Light and Matter
3. A New Theory of Matter
4. The Structure of Atoms and Molecules
5. The Stellar Atom-Building Machine
6. The Amazing Periodic Table
7. Ionic versus Covalent Matter
8. The Versatile Element: Carbon
9. The Strange Behaviour of Water
10. Matter in Solution
11. Interactions: Adhesion and Cohesion
12. Surface Energy: The Interfaces amongst Us
13. The Eloquent Chemistry of Carbon Compounds
14. Materials for Body Implants
15. The Chemistry of Food and Drink
16. Fuels and Explosives
17. The Air We Breathe
18. Materials: The Stone, Bronze, and Iron Ages
19. Again and Again: Polymers
20. Recycling Materials
21. Resistance Is Futile: Superconductors
22. Resistance Is Useful: Semiconductors
23. Out of Many, One: Composites
24. The Future of Materials

The Nature of Matter:
Understanding the Physical World
Course no. 1227 | 24 lectures (30 minutes/lecture)

SAVE UP TO £30

DVD ~~£54.99~~ **NOW £24.99**
CD ~~£35.99~~ **NOW £24.99**

+£2.99 Postage and Packing
Priority Code: 110778

For 25 years, The Great Courses has brought the world's foremost educators to millions who want to go deeper into the subjects that matter most. No exams. No homework. Just a world of knowledge available anytime, anywhere. Download or stream to your laptop or PC, or use our free mobile apps for iPad, iPhone, or Android. Over 500 courses available at www.TheGreatCourses.co.uk.

The Great Courses®, Unit A, Sovereign Business Park,
Brenda Road, Hartlepool, TS25 1NN. Terms and conditions
apply. See www.TheGreatCourses.co.uk for details.

FACEBOOK WANTS TO READ YOUR MIND

Facebook's Mark Zuckerberg recently claimed that technology will one day allow us to update our friends via thought. But as **Rita Carter** reveals, machines can already decipher our brains



CONSIDER A SELECTION of stereotypical movie scenes: 1. A witness to a crime walks hesitatingly along a line of blank-faced characters trying to identify the culprit. 2. A defendant pleads with the jury from the dock: “I didn’t do it – believe me!” 3. A victim screams: “All right – I’ll talk!” as some vile instrument of torture is applied to their flesh.

Now, in your mind, imagine the witness, defendant or victim lying in a brain scanner. Nearby, an image forms on a monitor. It’s fuzzy at first, but forms into a clear picture – maybe a face, an event or a string of words. The scanner has read the person’s mind and presented its contents.

The second type of scene has been a sci-fi staple for decades. But recently, ‘mind reading’ by brain imaging has taken some big steps into the real world.

German and US researchers recently produced speech that was communicated by a patient undergoing brain surgery. The words in the recording were translated from a readout of the electrical patterns generated in the patient’s brain.

This brain-to-text study is the latest to demonstrate that neurotelepathy – knowing what a person is experiencing by

interpreting their brain activity – is a reality, even if it is still relatively crude. Last year, a group of Yale researchers produced digital reconstructions of faces that were being viewed by people in an fMRI scanner (see ‘What is fMRI?’, p53). Again, the source of the images was the pattern of activity detected in the viewers’ brains. The published results suggest the reconstructed faces are as recognisable, or more so, than traditional photofits.

Prof Marvin Chun, who ran the study in his lab at Yale, says it has finally given him an answer to the question so often asked by strangers when they learn he is a psychologist: “They want to know if I can read their mind,” he says. “Now I have an answer. Yes. If I can get them in a scanner, I can.”

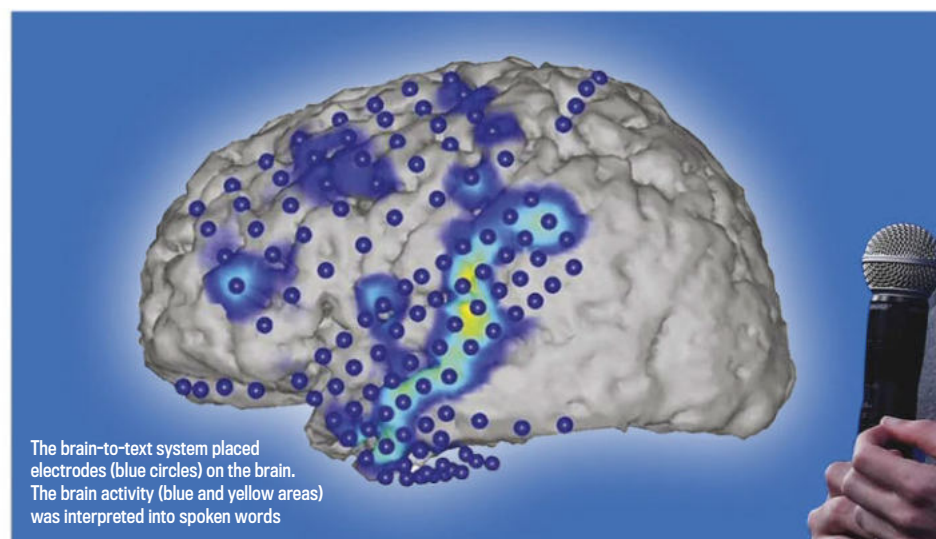
So far, there is a limit to what can be read. Alan Cowen, the Yale PhD student who designed the study, stresses that the volunteers willingly conveyed the information that was extracted. “We can only read active parts of the brain,” he explains. “So you couldn’t read passive memories – you would have to get the person to imagine the memory to read it. It’s a matter of time, and eventually, maybe 200 years from now, we’ll have some way of reading inactive parts of the



Above: Prof Martin Chun boasts that he can read minds
Below: EEG electrodes monitor brain activity



“One day, I believe we’ll be able to send full, rich thoughts to each other directly using technology”



The brain-to-text system placed electrodes (blue circles) on the brain. The brain activity (blue and yellow areas) was interpreted into spoken words



Could Facebook’s Mark Zuckerberg be correct?

➔ brain. But that's a much harder problem, as it involves measuring very fine details of brain structure that we don't even really understand."

Private thoughts

This doesn't put paid to the issue of privacy, however, because you don't necessarily have control over which parts of your brain are active. In a 2013 study, even more Hollywood-like, a Japanese group managed to recreate dreams. Brain activity was recorded from volunteers. This was then translated into a video of what they were likely experiencing during Rapid Eye Movement. The resulting films were more detailed than the dreamers' own recollections of their experiences.

Neurotelepathy is possible because the location of brain functions is pretty consistent across individuals. Almost anyone who looks at a face will show activation in an area on the left of their brain, just behind the ear. Looking at inanimate objects stirs activity in a different area. Thinking sad thoughts will activate different areas to happy thoughts. Saying 'aaaaah' involves different neurones to saying 'teeeee'.

Of course, there are differences between individuals. If you and I hear the word 'moon', our brains will not respond identically. For you, the word may jog images of astronauts, while in me it might trigger the notion of cheese. But activity correlating to hearing 'oooo', and imagining a silver disc will be common to us both. If you build a big enough database of different brains responding to the same things, you can arrive at a 'signature' for each stimulus.

One of the first studies to show that this method works was carried out at MIT in 2000. A group led by Prof Nancy Kanwisher showed images to volunteers while they were being scanned, then examined the readouts.

"Just by eyeballing the data, I correctly determined in over 80 per cent of the trials whether the subject was imagining faces or places," says Kanwisher. "I worried for a long time before we

published these data that people might think we could use an MRI to read their minds. Would they not realise the results obtained in my experiment were for a specific, constrained situation? That we used faces and places because we know which highly specific parts of the brain

process those two categories? That we selected only cooperative subjects who were good mental imagers? And so on. I thought, 'Surely, no one would try to use fMRI to figure out what somebody else was thinking?'"

But of course, people would.

"One day, I believe we'll be able to send full, rich thoughts to each other directly using technology," announced Facebook CEO Mark Zuckerberg during a recent Q&A session. "You'll just be able to think of something and your friends will immediately be able to experience it too."

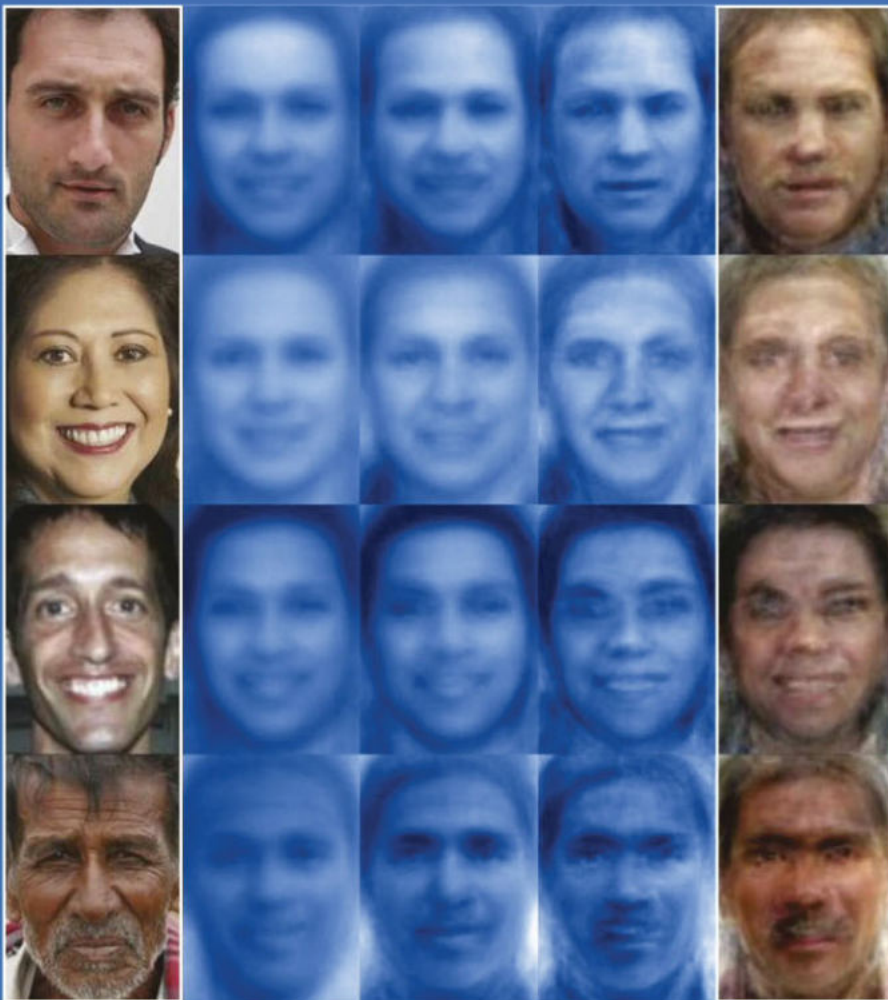
There is a massive practicality gulf between current experiments and Zuckerberg's vision. The brain-to-text experiment, for example, involved placing

FACE FACTS

On the left are the original faces that were seen by volunteers as part of the Yale study; on the right are versions created by a computer after reading their minds

ORIGINAL IMAGE

MACHINE VIEW



"Movie-style thought transference is currently impossible, but experimental neurotelepathy is creeping into use"

electrodes directly on the brains of patients during surgery. Meanwhile, the Yale face recognition study depended on a huge IT development project and hours of tedious fMRI scanning for the volunteers.

Even the most gung-ho neuroscientists hedge their bets about the future of neurotelepathy. Prof Jack Gallant at the University of California, Berkeley believes that thought-conveying helmets will eventually exist, but not for a long time.

“The most optimistic estimates are that you can recover one-millionth of the information that’s available in the brain at any given point in time,” Gallant says. “It’s probably smaller than that. Where we are today is just measuring a pale shadow of what you could potentially measure, if you had a better measurement technology.”

Health help

Even though movie-style thought transference is currently impossible, experimental neurotelepathy is slowly creeping into use. A ‘painometer’ is being developed that makes a person’s suffering visible to others. The consciousness level of patients undergoing surgery has been monitored to ensure they don’t start to feel the surgeon’s knife. Locked-in syndrome patients have been able to communicate simple thoughts such



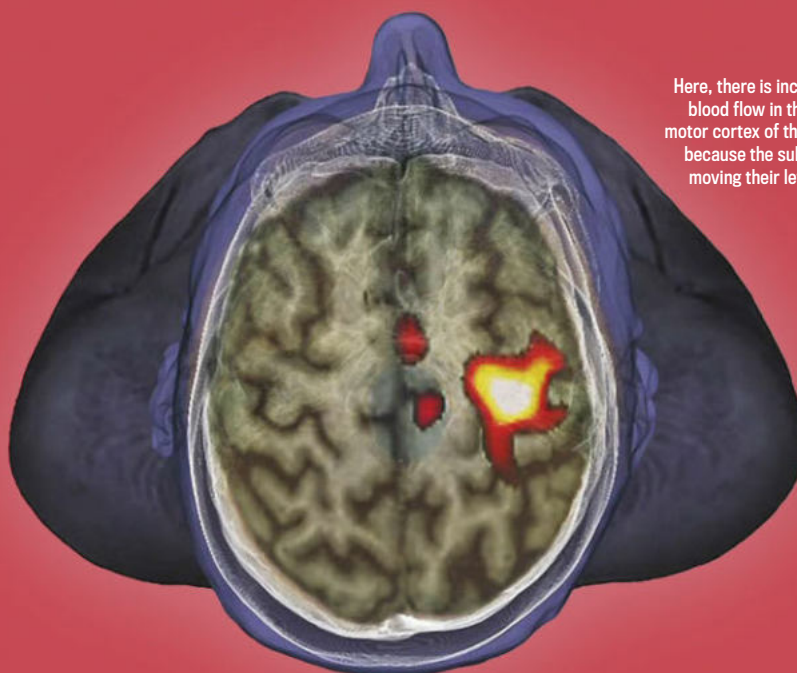
In a 2013 Japanese study, researchers managed to visualise the dreams of volunteers sleeping in an fMRI machine. These images were taken 31 seconds before waking (top) and 12 seconds before waking (above)

WHAT IS fMRI?

This technique allows scientists to measure brain activity. It is safe, easy to use, and quickly gives excellent results

FUNCTIONAL MAGNETIC RESONANCE Imaging (fMRI) shows what the brain is doing, as well as how it looks. Volunteers in fMRI experiments typically carry out a cognitive task, such as responding to stimuli, or calculating, recalling, or imagining something. Meanwhile, the scanner measures the blood flow to and from different parts of the brain and superimposes it onto an anatomical picture of the brain. The areas pulling in most blood are assumed to be those that are most active. This is because blood carries oxygen, which is the ‘fuel’ that brain cells use to generate electricity.

fMRI is the most common technology used to correlate brain activity with our thoughts, responses and perceptions. It seems to be safe and it’s good at pinpointing location. Other techniques, such as non-invasive EEG, in which scalp-mounted electrodes detect signals from the underlying brain, are faster but less precise.



Here, there is increased blood flow in the right motor cortex of the brain because the subject is moving their left hand

MIND READERS ON TRIAL

Could we see brain scanners used in criminal cases?

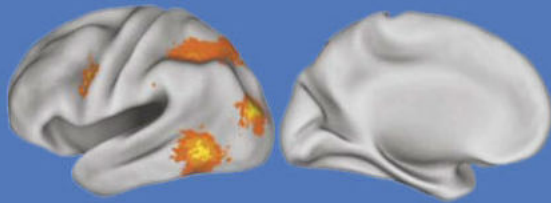
IN 2008, AN Indian court sentenced 24-year-old student Aditi Sharma to life imprisonment for murdering her ex-fiance. An EEG-based lie detection test was accepted as key evidence.

Brain-based lie detection has often been put before courts, but in most countries it is rejected as unreliable. In fact, India has since declared it inadmissible. One issue is whether the brain activity seen in lying is indicative of deception.

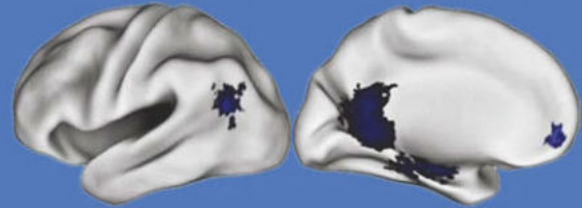
A major neural 'marker' of deception is high activity in the frontal brain areas that concoct stories. The assumption is that lying involves making things up while telling the truth does not. In standard lab tests the marker is pretty reliable, but a similar pattern of activity can occur in other situations giving false results. In one study, volunteers were shown a series of cards and asked to select one without saying which. When they saw the card again and were asked if it was the one they had noted, their brains reacted similarly whether or not

they were lying about having selected it. This suggests that merely investing something with meaning may cause your brain to react to it in a different way to other things.

A second question is whether the lie detector itself can be deceived, and a study at the Memory Lab at Stanford University showed how the system can be beaten. Twenty-four volunteers were shown 200 novel faces on one day. The next day, they were shown the faces again, along with 200 new faces mixed in. They then had to hide their memories – when they saw a familiar face, they had to say they didn't recognise it, and also had to claim they recognised unfamiliar faces (see image). Their brain activity convinced the machine that they were telling the truth when they were lying. Until lie detection cracks these problems, it is unlikely to appear in criminal courts. Given current progress, though, this may not take long. Meanwhile, Sharma has been released from prison pending appeal.



These images show the areas of the brain that lit up when someone pretended to see a familiar face for the first time



These images show the areas of the brain that lit up when someone pretended to recognise an unknown face

“Surely, no one would try to use fMRI to figure out what somebody else was thinking?”



Prof Nancy Kanwisher examined brain readouts from willing volunteers, but was concerned about potential backlash



as 'yes' or 'no' just by thinking them. These applications have succeeded because the 'signatures' of the experiences they convey are less complex than those associated with face perception or speech. But the principle of reading information from a brain is already established.

Mind-reading devices that benefit the sick are ethically unchallenging, but the idea of technology that can look into your head and see things you would rather keep to yourself is a different matter.

So far, the only brain reader to get out of the lab is the lie detector based on EEG or fMRI. It has been around for a decade. Once, in India, it helped convict a man for murder, though UK and US courts generally refuse to allow it. The companies

that sell it claim it can tell if a person is lying with 90 per cent accuracy. Yet these results come from closely controlled experiments and it is far less effective in the real world.

Legal aid

Sooner or later, neurotelepathy will almost certainly be good enough for law enforcement and intelligence agencies. Many find the prospect scary, but the cost of breaching mental privacy might outweigh the harm currently being done by our inability to see inside people's heads. Conscious eyewitness recall is terrible, and mistaken recognition is responsible for more convictions of the innocent than all other factors combined. Most people can detect lying at little better than chance. And if information must be extracted, surely brain scanning is more humane than torture? Like all technology, its value will depend entirely on how it is used. ■

RITA CARTER is a science lecturer, broadcaster and writer who specialises in the human brain

Red alert for the Sumatran tiger. Fauna & Flora International launches emergency appeal in response to 600% increase in poaching threat. Please respond by 21 September.

Photo: Evan Bowen-Jones/FFI



This Critically Endangered tiger has been pushed to the edge of extinction – maybe 500 remain. Give to stop the poachers at www.FFIsumatrantiger.org

A 600% increase in snares laid since 2011 has put FFI's anti poaching team on red alert. Habitat loss has already pushed the Sumatran tiger to the brink of extinction but now poachers have stepped up their efforts to snare these magnificent cats.

Fauna & Flora International (FFI) has put out an urgent call to the global community to save the last Sumatran tigers currently existing in the wild – and specifically to employ more rangers. There are now only around 500 Sumatran tigers left.

FFI is urgently seeking funds to step up their crucial conservation programme in Kerinci Seblat National Park, Sumatra, Indonesia. In order to safeguard the future existence of these magnificent creatures, it is vital that more rangers are employed

Right now, the Sumatran tiger faces a number of very serious threats, which are putting their very survival in jeopardy. And, sadly, they are all man-made threats.

Poaching is a constant danger for the elusive Sumatran tiger – and now poachers have **substantially** stepped up their efforts. Hunters make good money from the tiger's beautiful skin and demand is constantly growing. Also, its bones are illegally exported to use as ingredients in traditional Asian medicines.

What is really worrying now is that poachers have increased the number of tiger snares laid by 600% since 2011 and this year snares found have been at almost record levels.

This is against a backdrop of a very serious loss of habitat. In the last ten to 15 years, natural forest cover in Sumatra has been slashed by almost a staggering 40%. Now there is a newly emerging threat, discovered by tiger patrols - the growth of illegal coffee plantations in Kerinci Seblat National Park.

These majestic forest dwellers have been designated as Critically Endangered on the IUCN Red List, making the Sumatran tiger one of the most endangered tiger subspecies on the planet. This is a rating reserved for animals that face an extremely high risk of extinction in the wild.

Latest surveys have indicated that there may now be as few as 500 existing in the wild. Kerinci Seblat National Park is one of the last places on Earth where they can still be found.

Today, 170 tigers live in and around Kerinci Seblat National Park – the largest known population of tigers anywhere in Sumatra. Since 2007 the number of tigers in the park has stabilised and begun to slowly grow – largely thanks to the vital work of FFI's Tiger Protection and Conservation Programme. However, now the upsurge in poaching puts these gains under threat.

Debbie Martyr, FFI Team Leader of the Kerinci Tiger Project in Sumatra, says:

"So far this year our ranger teams walked almost 1100 miles on forest patrols in and bordering the national park and destroyed more than 60 active tiger snares - an increase of 600% since 2011. That is why we need to step up patrol regimes".

One of the Sumatran tiger's final strongholds is under threat from a massive increase in poaching. Action is needed now.

- **£83,131 is needed to help us fund more rangers and step up action against the poachers in Kerinci Seblat National Park.**
- **This is one of the final strongholds of the incredibly rare Sumatran tiger, a place where the battle to save the Sumatran tiger will be won or lost.**
- **FFI's work here could be all that stands between the Sumatran tiger and extinction.**

Tiger populations are dreadfully fragile.

If FFI cannot recruit more rangers to protect the tigers against the increased efforts of the poachers all our good work could be undone.

For all of these reasons, it's now absolutely vital that we increase our patrols to protect tigers from poachers – and work towards greater protection for their delicate habitat.

If we're going to save the Critically Endangered Sumatran tiger from complete extinction, it's vital that we have the means to take action now.

FFI must raise £83,131. To do that, the charity is calling on readers to make an urgent contribution today.



Photo: Gill Shaw

"If you value the natural world – if you think it should be protected for its own sake as well as humanity's – then please support Fauna & Flora International."

**Sir David Attenborough, OM FRS
Fauna & Flora International vice-president**

Please send a gift, by no later than 21 September, to help safeguard the future survival of the last few remaining wild Sumatran tigers.

Together, we can save the Sumatran tiger from extinction – but only if we take action immediately.

To take action for the Sumatran tiger please go to www.FFIsumatrantiger.org or cut the coupon.

If the coupon to the bottom right is missing, please send your cheque (payable to FFI) to: FREEPOST RRHG-GBGG-CAGG, Fauna & Flora International, Sumatran Tiger Appeal, Jupiter House, Station Road, Cambridge, CB1 2JD by 21 September.

Stop press - Poachers kill Tiger in Kerinci

"We knew this tiger, a large male. To see it reduced from a beautiful wild animal to a pile of meat and guts made us all very angry".

Yoan Dinata, Tiger Protection Team, Kerinci Seblat

Fauna & Flora International, founded in 1903, was the world's first international conservation organisation. Today its work spans the globe, with over 140 projects in more than 40 countries. It has a strong history of finding creative solutions to conservation problems and of working with local communities. FFI is supported by the most eminent scientists and members of the conservation movement.

Dear readers: Fauna & Flora International (FFI) has launched an emergency appeal, backed by Sir David Attenborough, to raise £83,131 to save the Critically Endangered Sumatran tiger.

These items are vital to help save the remaining Sumatran tigers from extinction.

£5,212 could help fund two new rangers posts and buy essential equipment – rucksacks, uniforms, sleeping bags, cooking equipment, field radios and compasses.

£2,500 could buy a pick-up van to help a patrol move around quickly to prevent poaching.

£400 could buy camping equipment and boots.

£72 could buy first aid kits to treat injured rangers whilst out on patrol.

£32 could help buy a field radio, essential to getting extra help if poachers are spotted.

Donations large or small will help us save the Critically Endangered Sumatran tiger from the 600% upsurge in the poaching threat.

Cut the coupon below and return it to FFI, together with your gift, to help save the Critically Endangered Sumatran tiger. Alternatively, go to www.FFIsumatrantiger.org. Thank you.

I want to help save the remaining 500 Sumatran tigers today, with a donation of £



Title _____ Forename _____
Surname _____
Address _____

Postcode _____
Email _____
Phone No _____

☐ I enclose a cheque payable to **Fauna & Flora International** OR
☐ I wish to pay by credit/debit card

Type of card: Visa/Amex/Mastercard/Maestro/CAF

Card No: _____

Start Date: _____ Expiry Date: _____

Issue Number (Maestro only): _____

3 digit security code: _____ (Last three digits next to the signature)

Please note: If Fauna & Flora International succeeds in raising more than £83,131 from this appeal, funds will be used wherever they are most needed.

**Please return to: Sumatran Tiger Appeal,
FREEPOST RRHG-GBGG-CAGG,
Fauna & Flora International, Jupiter House,
Station Road, Cambridge, CB1 2JD.**



You can call 01223 431991 to donate now.

Or go to: www.FFIsumatrantiger.org to donate online.

Registered Charity No. 1011102. Registered Company No. 2677068. PR ST15BF

UNCOVERING NATURE'S HIDDEN BEAUTY



1665

Robert Hooke only had an early optical microscope at his disposal, yet he still created intricate drawings

Robert Hooke's *Micrographia*, published 350 years ago this month, revolutionised the way we see the natural world. **Michael Banks** takes a closer look at the cutting-edge imagery shaping our knowledge today



NOT MANY BOOKS claim to change the way we view the world, but a 1665 publication by the English physicist Robert Hooke did just that. The book was called *Micrographia* and featured some 60 drawings of animals and other objects, based on observations that Hooke made using his microscope.

While such microscopes had been around since the 1590s, it was *Micrographia* that first captured the public's imagination, advancing microbiology as a branch of science.

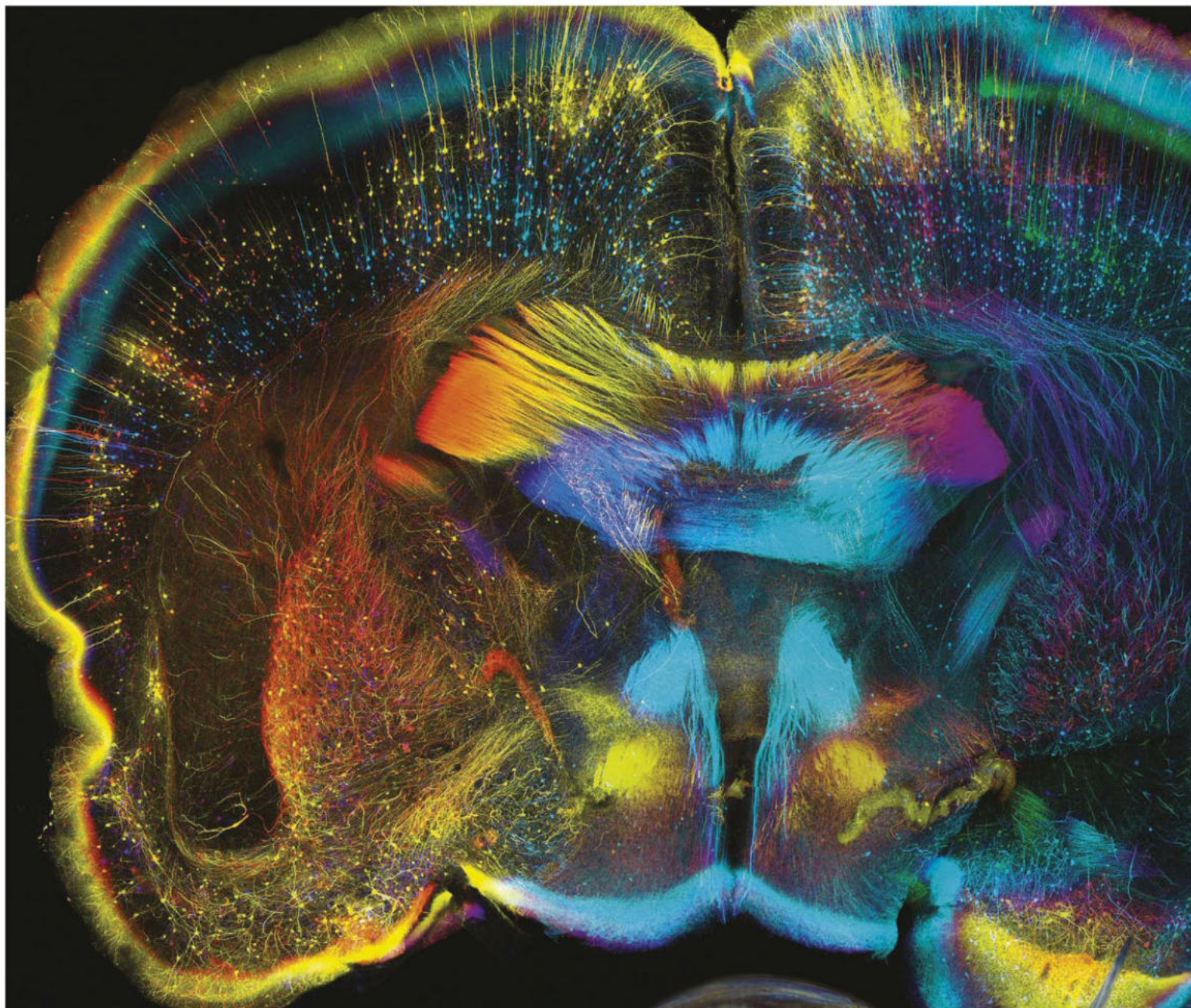
Now celebrating its 350th anniversary, *Micrographia* has become a timeless classic, comparable in impact with Isaac Newton's *Principia* and Charles Darwin's *On The Origin Of Species*. "What makes Hooke's *Micrographia* so special is that it also contains the first use of the word 'cell' in biological terms," says Kim Findlay, Head of Bioimaging at the John Innes Centre in Norwich. While Hooke's humble microscope was a powerful instrument back then, it pales in comparison to some of its modern cousins that scientists now use to study the intricacies of the microscopic world.



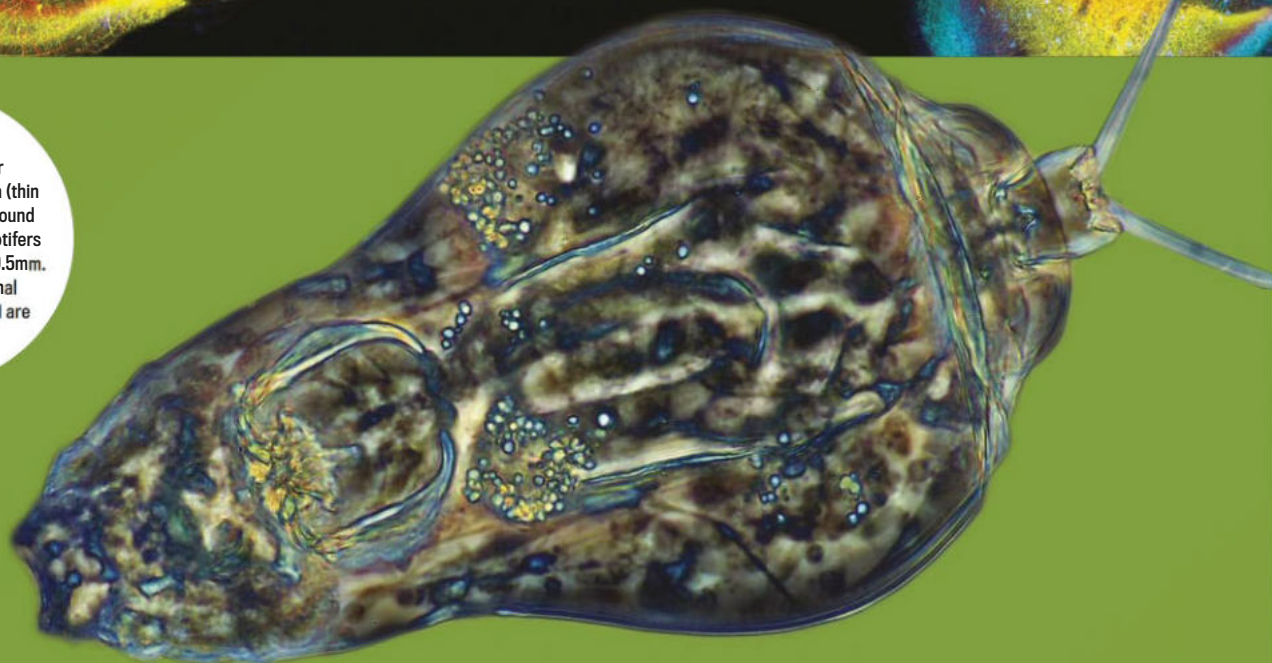
2015

Today, it is possible to create detailed 3D images of specimens, such as this Oriental rat flea (*Xenopsylla cheopis*)





Rotifers are known as 'wheel animals'. Their name comes from the cilia (thin protuberances) that are found around the mouth. Most rotifers measure between 0.1 and 0.5mm. In this image, the internal organs of the tiny animal are clearly visible



BROUGHT INTO FOCUS

THIS IS A section of a mouse brain that was imaged using confocal microscopy. The psychedelic strands running through it are neurones, which have been colour-coded according to depth. This image, taken by Luis de la Torre-Ubieta, was part of his research investigating how neurones take shape in their development.

Confocal microscopy was developed by computer scientist Marvin Minsky from the Massachusetts Institute of Technology in the mid-1950s. In conventional microscopy, although a small part of the sample is illuminated at one time, some of the reflected light scatters, which can result in slightly blurry images with a top resolution of 200nm. Confocal microscopy gets around this problem by adding a small pinhole aperture, which only lets in light from the desired focal spot of the sample. This produces sharper pictures, getting close to a resolution of around 100nm.

Scientists have used confocal microscopy to view muscle fibres in detail, and to show how living cells grow and divide.

The neurones are coloured according to depth. Red (top), orange, yellow, purple, blue and green (bottom)

SEEING THE INVISIBLE

HERE IS A tiny aquatic animal known as a rotifer. Many microscopic objects such as rotifers, bacteria and cells are colourless or transparent, making them tricky to image directly. It's not always possible to stain such samples as it could harm them. This is where the phase contrast microscope comes in. The technology was developed by the Dutch physicist Frits Zernike

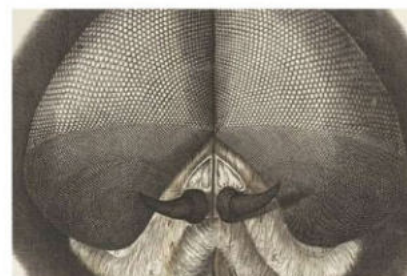
in the 1930s, who was later awarded the 1953 Nobel Prize in Physics for his work.

When light travels through a transparent or colourless object, there is a slight alteration in 'phase' – a measure of how much a light wave changes compared to the uninfluenced light. The phase contrast microscope translates this change in phase into a difference in brightness, so that transparent objects shine out in contrast to their surroundings. The phase contrast microscope is useful because it allows organisms and cells to be viewed while they're still alive and has a top resolution of around 200nm.

HOOKE'S KEY DISCOVERIES

Fly's eye

When investigating the eyes of insects, Robert Hooke chose a drone fly as it had "the largest cluster of eyes in proportion to its head". He estimated the number of "hemispheres" in his sample at 14,000.



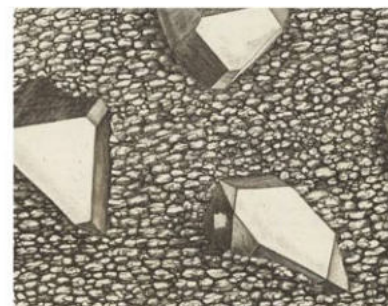
Plant cell

During his observations of the internal honeycomb-like structure of this slice of cork, Hooke first coined the biological term 'cells' to describe the individual repeating components. He saw similar structures in other plants too.



Urine crystals

In his typically curious fashion, Hooke put samples of urine under the microscope noting that he had "often observ'd the gravel or sand of urine". Under the microscope, he found that the crystals looked yellow, red, brown and white.



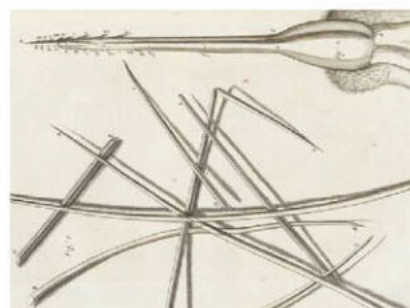
Nettle hairs

Hooke decided to put nettle leaves under his microscope in order to figure out exactly what it was that gave them their sting. He correctly determined that the "bodkin-like" bristles were responsible.

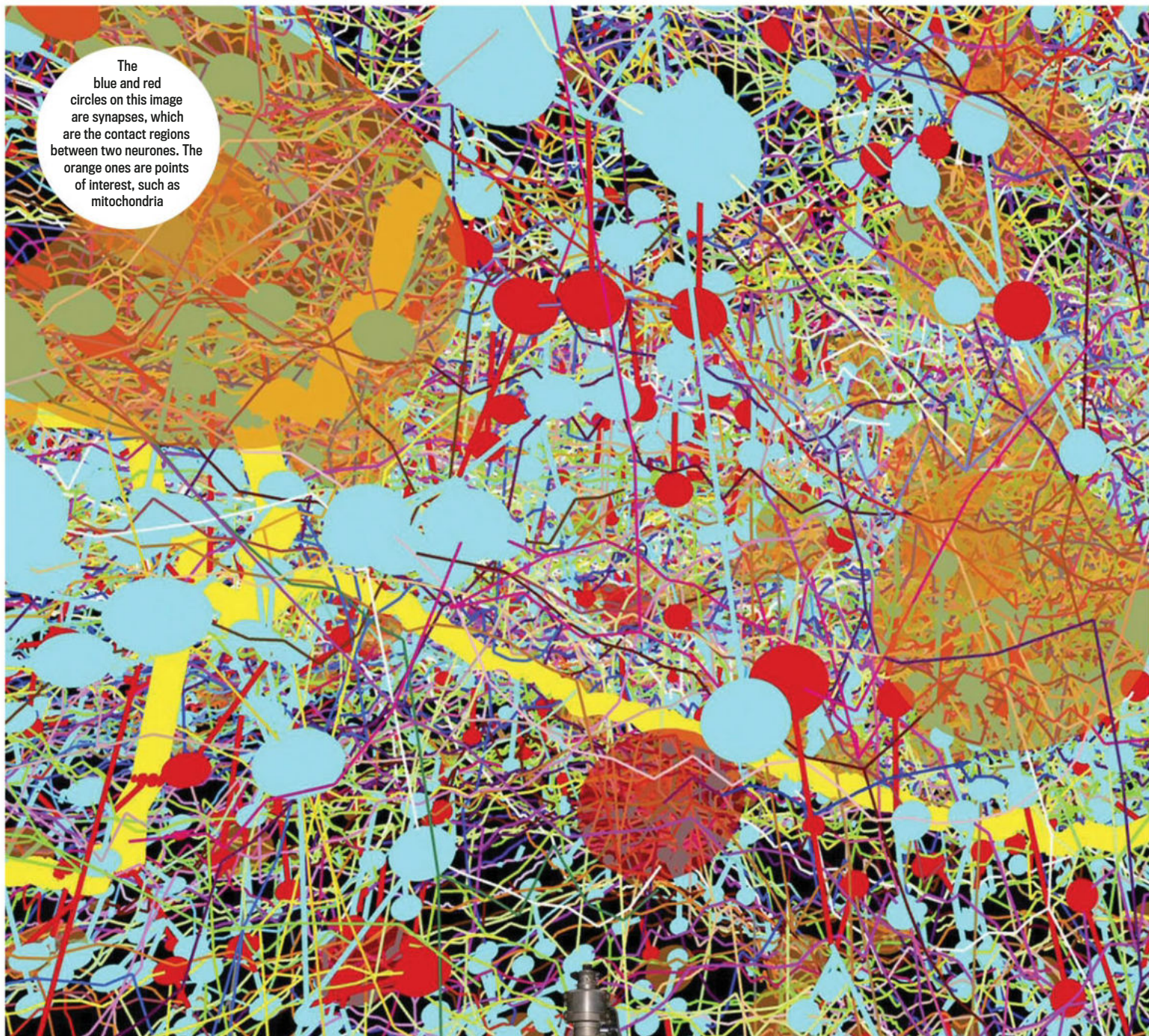


Bee sting

This intricate drawing by Hooke shows the barbs along the sides of the bee sting's shaft. He commented that they were "like so many thorns growing on a briar". He also drew the bulbous venom sac at its base.



The blue and red circles on this image are synapses, which are the contact regions between two neurones. The orange ones are points of interest, such as mitochondria



HISTORY REVEALED

KEY BREAKTHROUGHS
THAT TRANSFORMED
THE WORLD OF
MICROSCOPY



1931

Electron microscope

The properties of visible light mean that it is not possible to resolve features less than about half a micrometre. The invention of the cathode ray tube made it possible to create a microscope that used beams of electrons instead of light. This new method of microscopy was capable of resolutions of 50nm.



1934

Phase contrast microscope

This microscopy technique allows scientists to observe features of biological specimens that would ordinarily be transparent to an optical microscope. The microscope works by taking advantage of the fact that light travels at different speeds through different materials. It was developed by Frits Zernike (pictured).



JOINING THE DOTS

THIS IS A reconstruction of the nervous system of a fruit fly larva, with images taken by a Transmission Electron Microscope (TEM).

An animal's nervous system controls everything it does, from moving, to thinking, to breathing. The yellow line through this image represents a neurone that detects vibrations, surrounded by hundreds of others. This image was taken as part of research to map out the neural circuits of animal brains.

TEM is the undisputed king of microscopes, allowing scientists to image individual atoms with a resolution better than 0.1nm. The first TEM was built in 1931 by the German electrical engineer Max Knoll and the German physicist

Ernst Ruska, who later went on to win the Nobel Prize in Physics in 1986. A TEM strikes a sample with an electron beam that is focused using magnetic fields. It requires a very thin sample (around 100nm thick) so that the beam can pass through it. At the bottom of the microscope, electrons hit a phosphor screen, which gives rise to visible light. Electrons scattered by atoms in the sample cannot make it to the bottom, resulting in a 'shadow image' of the specimen. Regions of the sample are displayed differently according to what elements are present – paler for lighter elements, darker for heavier ones.

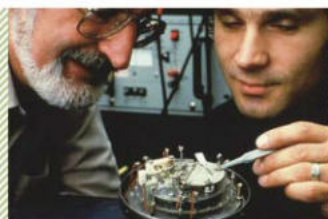
The samples need to be put in a vacuum inside the microscope because molecules in the air would scatter the electrons, giving no image. Therefore, it is not possible to study live samples in an electron microscope.



1951

Field ion microscope

Erwin Müller (pictured) invented the first microscope capable of imaging atoms. The metal under investigation is made into sharp tip and is placed in a vacuum with a tiny amount of imaging gas. A high voltage is applied to the tip, causing the gas atoms near it to become ionised. They are then repelled towards a screen to form an image.



1981

Scanning tunneling microscope

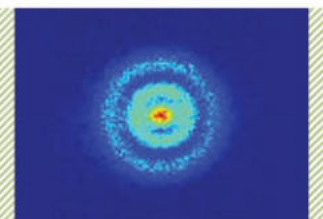
STMs use quantum tunneling to create images at an atomic level. The technique works by scanning a fine tip across a surface of the material under investigation. Electrons can 'tunnel' across the empty space creating an electric current that is then used to form an image.



1986

Atomic force microscope

These microscopes were developed from scanning tunneling microscopes. They scan a very sharp tip across the surface of a sample and maintain the force between the two at a constant level. The bending of the tip due to atomic forces is then detected and used to create an image of the surface at a high resolution.



2009

Quantum microscope

A Dutch team used photoionisation to produce this image showing the nucleus and electron orbital of a hydrogen atom. They placed the atom in an electric field and hit it with lasers. This caused the ionised electron to escape from the atom and strike a detector, building an image of the atom's electron orbitals.

POLARISED PLANKTON

THIS COLOURFUL CREATURE is a species of water flea. These are tiny crustaceans often found in freshwater environments. It was photographed using a polarised light microscope. This kind of microscope allows you to see

'birefringent' structures (those that bend light in two directions) more clearly. Collagen and crystals are two such structures. In the case of this water flea, this technique allows us to see its form and inner workings in sharper contrast.

Polarised light microscopy takes advantage of the way that light behaves. Light travels as a wave, which can oscillate in

many different orientations. But it is possible to 'polarise' light so that it is made to fluctuate along one single axis. This type of light allows us to study structures that appear different when viewed from multiple angles.

Polarised light microscopes have a top resolution of 200nm are often used in the fields of geology, medicine and biological research.

Daphnia water fleas, like the one pictured, measure up to 5mm. They live in most types of freshwater and are an important part of the food chain





The compound eye of the earwig, like most insects, consists of many photoreceptor units called 'ommatidia'

This weevil SEM appeared in our March 2014 issue - but we loved it so much we thought we'd show it again



THE THIRD DIMENSION

THIS IMAGE OF an earwig was created with a Scanning Electron Microscope (SEM). The photographer used LEDs to illuminate the insect in a unique way, taking inspiration from portraits painted by artists in the 17th Century.

While light offers a powerful way to take scientific images, it cannot resolve anything much smaller than the wavelength of light. In fact, it was long thought

that anything on an atomic scale would be impossible to see since the wavelength of light is thousands of times larger than the distance between two atoms. That changed with the introduction of the SEM, which was pioneered in the late 1940s by Charles Oatley and colleagues at the University of Cambridge.

The SEM consists of a source of electrons - small subatomic particles that have wavelengths less than 1nm - that are focused into a tight beam that strikes the surface of a sample. This beam causes a tiny part of the sample's surface to emit electrons, which

are picked up by a detector to create an image of the shape of the object under study. If a sample were completely flat, the image would be monotone. As soon as there is some 3D shape to the surface of the sample, more electrons are detected from the side of the sample that's facing the detector, giving rise to increased brightness.

SEMs have a resolution of about 1nm and allow scientists to determine elements in a sample and even fabricate structures on a nanometre scale. ■

DR MICHAEL BANKS is the news editor of *Physics World*, which is the magazine of the Institute of Physics

DISCOVER MORE!

To see more stunning images from Robert Hooke's *Micrographia*, visit bit.ly/NaturesHiddenBeauty

Feed your mind



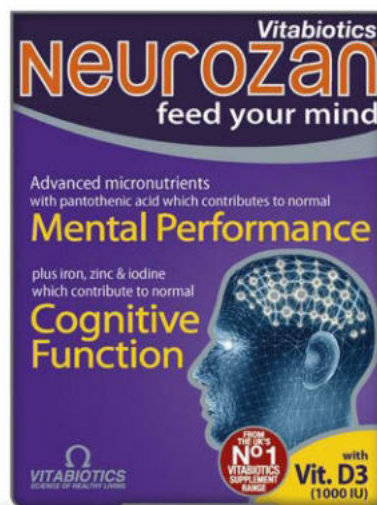
Micronutrients with iron, zinc & iodine,
which contribute to normal **cognitive function**

Neurozan® is an advanced, comprehensive formula to help safeguard your daily intake of essential vitamins and minerals. Including iron, zinc and iodine which support normal **cognitive function** and pantothenic acid which supports normal **mental performance**.

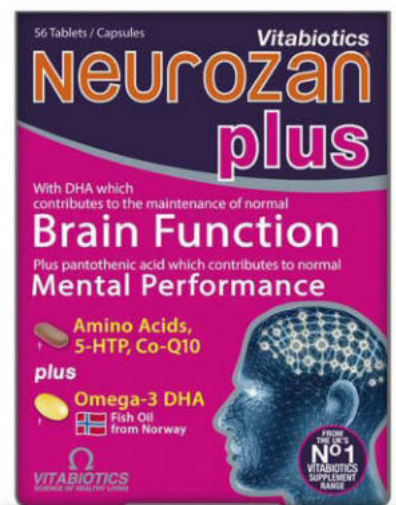
Neurozan® Original contains a specially developed combination of nutrients and is certified by **Food For The Brain**.

Neurozan® Plus dual pack provides even greater nutritional support with high purity Omega-3 from Norway.  DHA helps to maintain normal **brain function**[†].

So if you're looking for a supplement that's different, keep **Neurozan®** in mind.



ORIGINAL (1000 IU)



DUAL PACK WITH DHA

Neurozan® tablets

Neurozan® is certified by pioneering charity **FOOD FOR THE BRAIN**. www.foodforthebrain.org

From , chemists, Waitrose, Holland & Barrett, health stores & www.neurozan.com

[†]A beneficial effect is obtained with a daily intake of 250mg DHA. *Nielsen GB ScanTrack Total Coverage 52 w/e 31 Jan 2015.


**Britain's No.1*
supplements**


THE QUEEN'S AWARDS
FOR ENTERPRISE
INNOVATION
2013


VITABIOTICS
SCIENCE OF HEALTHY LIVING

QA

YOUR QUESTIONS ANSWERED

BY OUR EXPERT PANEL



SUSAN BLACKMORE

Susan is a visiting psychology professor at the University of Plymouth. Her books include *The Meme Machine*



DR ALASTAIR GUNN

Alastair is a radio astronomer at the Jodrell Bank Centre for Astrophysics at the University of Manchester



ROBERT MATTHEWS

After studying physics at Oxford, Robert became a science writer. He's Visiting Reader in Science at Aston University



GARETH MITCHELL

Starting out as a broadcast engineer, Gareth now writes and presents *Click* on the BBC World Service



LUIS VILLAZON

Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach The Ground*

EMAIL YOUR QUESTIONS TO questions@sciencefocus.com

or post to *Focus Q&A*, 2nd Floor, Tower House, Fairfax Street, Bristol, BS1 3BN

Q RICHARD SHAW, BROMLEY

What happens to old aeroplanes?

A MANY END UP in so called 'boneyards' like that at Victorville in California (pictured). Located at the edge of the Mojave Desert, the arid environment is ideal for storing aircraft as there is little risk of corrosion. The Victorville facility is based at Southern California Logistics Airport and has 500 parking spaces for old planes.

The boneyards of the world are increasingly filling with Boeing 747s; these jumbo jets are gradually being replaced by newer planes such as the Airbus A350 and the Boeing 787,

which are capable of flying longer hauls more efficiently. Increasingly, super jumbos are only required on routes across remote regions with fewer airfields. In this situation, four engines are a safer option.

Boeing is currently scaling production back to just one 747-800 model each month. If that reflects a wider decline in demand for big planes, then the Victorville facility had better free up plenty more parking spaces in its famous boneyard for the iconic beasts of the sky. **GM**



The planes patiently waited to be loved once again

PHOTO: CORBIS

In Numbers

\$100m

has been contributed to the search for extraterrestrial intelligence by Russian billionaire Yuri Milner

Q MARK REYNOLDS, MILTON KEYNES

Why are some people left-handed?

A ONE SIMPLE ANSWER is that handedness runs in families and is inherited. Scientists have recently found a network of genes that is responsible for body asymmetry and also influences handedness. The deeper question is why about 90 per cent of people are right-handed and only 10 per cent left-handed. In other species that show a hand (or paw) preference, including chimpanzees, polar bears, dogs and cats, the split is about equal. One theory relates handedness to language, because most people's language centres are in the left hemisphere. Another is that in a mainly right-handed culture, being left-handed might give a small advantage in outwitting an opponent. This may explain the success of many left-handers at the top level in such sports as fencing, tennis and cricket. Working against this is the value of cooperation, which is easier when everyone is right-handed. So these combined pressures might explain the stable 90:10 split. **SB**



A single-celled Xenophyophore measuring 20cm in width, located in the Atlantic Ocean

Q CLAIRE MARSHALL, READING

What animals live at the bottom of the Mariana Trench?

A WHEN DON WALSH and Jacques Piccard made the first expedition to the bottom in 1960, they reported seeing a flatfish but they didn't take photographs. Other marine biologists now think this was probably a sea cucumber. No other survey has found fish deeper than 8,145m and the Mariana Trench reaches down

to almost 11km. But it's not devoid of life. There are shrimp-like amphipods – a type a crustacean – the size of rabbits living there, as well saucer-sized animals called Xenophyophores. These look a lot like coral but are actually a single cell with multiple nuclei. They feed like an amoeba, by engulfing particles of ocean debris. **LV**

Q ELLIE FOWLDS, TORBAY

Do plants really grow better if they 'hear' human voices or music?

A THERE IS SOME evidence that they might. A 2014 study at Osmania University in Hyderabad, India found that roses grew faster when exposed to Indian classical music than Western rock music or silence. And a 2011 study at Zhejiang University in China reported 10 per cent faster mushroom growth when the fungi enjoyed a mixture of music and cricket chirps. Sound vibrations have also been shown to activate certain plant genes. But in these studies the researchers could hear the music too, so it may be that people do a better job of tending plants when they listen to music they like. **LV**



Maybe Prince Charles was right all along?

According to our production editor, left-handers are best... but we think she's biased

QUESTION OF THE MONTH

A typical visualisation of the main asteroid belt. But in reality, large asteroids are much more spread out



0 TONY HERSH, NEWBURY

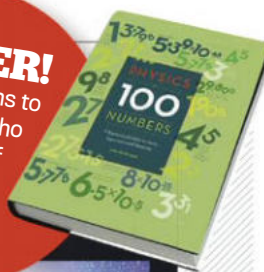
How do spacecraft avoid hitting asteroids and meteoroids?

A THEY DON'T! THE main asteroid belt is actually much less populated than is often depicted in the movies. It has a volume of about 50 trillion trillion cubic kilometres (which would take about 35 million Suns to fill!). Astronomers estimate the number of asteroids bigger than about 1km in size in the main asteroid belt is about 80,000. This means that, on average, the distance between large asteroids is about 17 million kilometres. Even if we include estimates for the number

of smaller asteroids in the main belt, we still find that the average distance between asteroids is millions of times the size of a typical spacecraft. Outside the main asteroid belt, the average distance between potentially hazardous objects is millions of times greater still. So, the chances of an accidental collision between a spacecraft and an asteroid are actually extremely small. Hence, mission planners don't need to take any special steps to avoid asteroids and meteoroids. **AG**

WINNER!

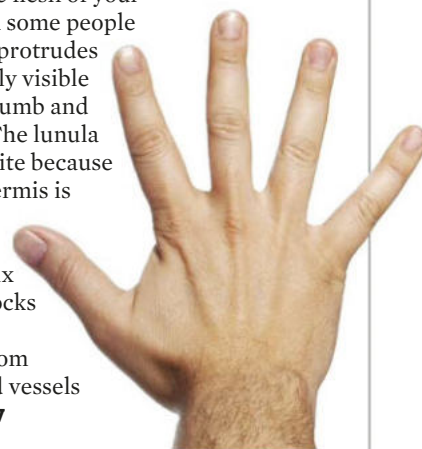
Congratulations to Tony Hersh who wins a copy of *Physics In 100 Numbers* (Apple Press, £12.99)



0 CALUM BALL, WORTHING

What are the white semi-circles at the bottom of our nails?

A YOUR NAILS ARE made from keratin secreted by a layer of living tissue at the base of the fingernail called the nail matrix. The moon shape, or lunula, is the part of the matrix that pokes out from under the flesh of your finger. In some people it barely protrudes and is only visible on the thumb and big toe. The lunula looks white because the epidermis is thicker beneath the matrix and it blocks the pink colour from the blood vessels below. **LV**



0 JOHN LOCKE, PRESTON

Why doesn't a Cadbury Flake melt in the microwave?

A ALTHOUGH FLAKE IS made from milk chocolate, the manufacturing process gives it a different arrangement of fat and cocoa solids, so the melting fat isn't able to lubricate the cocoa particles to the point where they can flow. In a bain-marie, a Flake will never melt. In the microwave, it eventually just burns. **LV**



Ruining a Cadbury Flake is a pretty heinous crime

TOP 10 FASTEST STEEL ROLLER COASTERS



1. Formula Rossa
Location: Ferrari World,
United Arab Emirates
Speed: 240km/h (149mph)



2. Kingda Ka
Location: Six Flags
Great Adventure, USA
Speed: 206km/h (128mph)



3. Top Thrill Dragster
Location: Cedar Point, USA
Speed: 190km/h (118mph)



4. Dodonpa
Location: Fuji-Q
Highland, Japan
Speed: 172km/h (107mph)



5. Superman: Escape From Krypton
Location: Six Flags Magic
Mountain, USA
Speed: 167km/h (104mph)



6. Tower Of Terror
Location: Dreamworld,
Australia
Speed: 160km/h (99mph)



7= Steel Dragon 2000
Location: Nagashima Spa
Land, Japan
Speed: 153km/h (95mph)



7= Fury 325
Location: Carowinds, USA
Speed: 153km/h (95mph)



9. Millennium Force
Location: Cedar Point, USA
Speed: 150km/h (93mph)



10. Leviathan
Location: Canada's
Wonderland, Canada
Speed: 148km/h (92mph)

Q HARRY CALDER, BIRMINGHAM

How does light travel down a fibre optic cable?

A AT THE CORE of the cable is a strand of plastic or pure optical glass about 0.01mm in diameter.

Surrounding it is a highly reflective cladding with a different refractive index to that of the core. The refractive indices of each material are engineered to ensure that light always reflects back off the cladding and is never absorbed by it, regardless of whether the cable is straight or bent round. It's a bit like carrying a torch through a long winding tunnel lined with perfect mirrors. **GM**

Fibre optics can be used to transmit light and telecommunications



Q JESSICA CONNOR, BRIGHTON

Can the Sun shining through glass really cause house fires?

A IT MAY SOUND like an urban myth, but it can and does happen. Fish tanks, jam jars and even glass door knobs have been implicated in focusing the Sun's rays sufficiently to cause smouldering, followed by a full-scale blaze. Earlier this year, London Fire Brigade said that 125 fires have been triggered by the Sun's rays over the last five years – and warned that the risk exists during the winter as well as summer. That's because the Sun's rays bathe the Earth in a constant flow of thermal energy spread over each square metre. This energy is too dilute to ignite paper, wood or other combustible substances, but if the rays are focused, it becomes concentrated enough to exceed the threshold for combustion. Magnifying



Even a glass left in the Sun can focus light enough to start a fire

glasses do this very effectively, refracting the rays and bringing them to a tight focus. But even fragments of glass can have some focusing effect – with potentially disastrous consequences. **RM**

Q ALEX ROUND, LONDON

Can a planet's atmosphere get bigger over time?

A THE VOLUME OR thickness of a planet's atmosphere depends on its temperature, its composition and the planet's escape velocity. The escape velocity depends only on the mass of the planet. Although planet masses can change, these changes are so tiny compared to the total mass of the planet that the escape velocity remains essentially constant.

The temperature of planetary atmospheres can change significantly due to changes in solar irradiance, and

higher average temperatures would result in a larger atmosphere. Composition changes, which can occur due to geological processes or the transference of gases in and out of the atmosphere, also affect the size of the atmosphere. A smaller average mass of the atmosphere's constituents would result in a larger atmosphere. So, planetary atmospheres can become larger (or smaller) over long timescales due to environmental, geological and biological processes. **AG**

WHAT IS THIS?



KNOW THE ANSWER?

Submit your guess now at sciencefocus.com/qanda/what

LAST MONTH'S PICTURE

Nobody correctly guessed that these are pillars from EHD patterning!



? Did you know?

Cracker butterflies are the noisiest butterflies in the world. Their cracking forewings can be heard from 30m away



Q ALAN DAWES, DUNDEE

Why does heat make roads appear wet in the distance?

A ON HOT DAYS, air just above the road can become hotter and less dense than air higher up. The optical properties of this 'inversion layer' can lead to light rays from the sky – that would otherwise hit the road – curving upwards. This creates the illusion that they have bounced off a pool of water on the road. **RM**



Q JOAO SANTA-CLARA, YORK

How are TV viewing figures calculated?

A TV RATINGS ARE compiled daily by the Broadcasters' Audience Research Board. BARB recruits 12,000 people across 5,100 households representative of the overall UK viewing public. As well as demographics and geography, the panel is selected according to platform, whether that's a TV set, desktop computer, laptop or tablet. The devices log data about what members of the household are watching. BARB computers rush the figures out to the broadcasters within hours. **GM**



There's real research behind television viewing figures



Air quality is a problem in China, but pollution is rising at a slower rate than during the Industrial Revolution

Q DOUGIE LINDSAY, GALASHIELS

With the current rate of pollution, when will the Earth become uninhabitable for humans?

A IT WON'T. HUMANS are not like yeast, which continues to metabolise in an uncontrolled manner until it is poisoned by its own waste products. As human pollution levels rise, the political imperative for us to do something about it increases as well. The Great Smog of London in 1952, which killed 4,000 people, was followed four years later by the Clean Air Act. Similar legislation in the US has seen the overall emissions of air pollutants fall by about 60 per cent in the last 35 years. The US 1990 Oil Pollution Act required oil tankers to have double hulls to reduce the risk of spills. The 1987 Montreal Protocol eliminated almost all CFCs from industrial and consumer products worldwide. Leaded petrol and the pesticide DDT are also

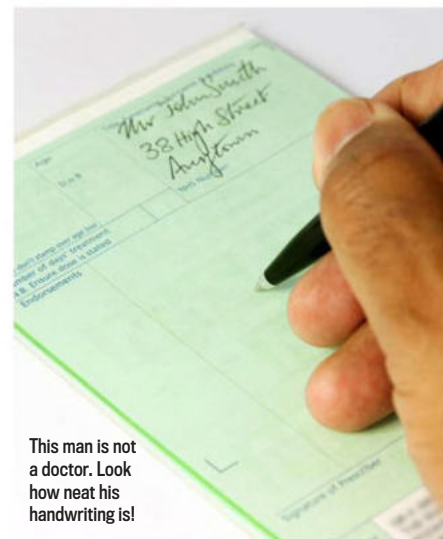
banned in most places. Air and water pollution are still a major problem in newly industrialised regions, particularly China, India and South America. But even then, pollution is rising more slowly than when the West went through the Industrial Revolution. This is because of better awareness and technology, as well as pressure from the rest of the world.

Global population is expected to peak around 10 or 11 billion. With care, it's possible that we may be able to sustain a habitable planet for that many humans more or less indefinitely. We may still become extinct through climate change, disease, nuclear war or meteorite impact, but humanity probably has enough foresight and resources to avoid poisoning itself to death. **LV**

Q SAM LOWRY, LEAMINGTON SPA

Why don't doctors adjust for age and size when prescribing drugs?

A THEY DO, THOUGH exactly how depends on both the patient and the medicine. For example, elderly patients often have liver and kidney function issues, which reduces the dose they can tolerate. In contrast, babies and toddlers are so small that their response to drugs depends critically on their weight, sometimes unpredictably. Even the gender of the patient can play a role in deciding dose. Then there's the type of drug: some are fat-soluble, so the correct dosage depends on Body Mass Index (BMI) – that is, total weight divided by the square of height – while other drugs are water-soluble, where dosage is better based on lean body mass. Yet another complication comes from the so-called therapeutic index of a drug – roughly speaking, how big a dose can be given before benefit turns into toxicity. Calculating the right dosage then depends on striking a balance between giving a high enough dose to tackle the condition, but not so high that it does more harm than good. According to Prof Donald Singer of the British Pharmacological Society, this is often the case with cancer therapy and some powerful antibiotics, and getting the dosage right for a specific patient can be very challenging. **RM**



This man is not a doctor. Look how neat his handwriting is!



HOW IT WORKS

PROJECT SOLI

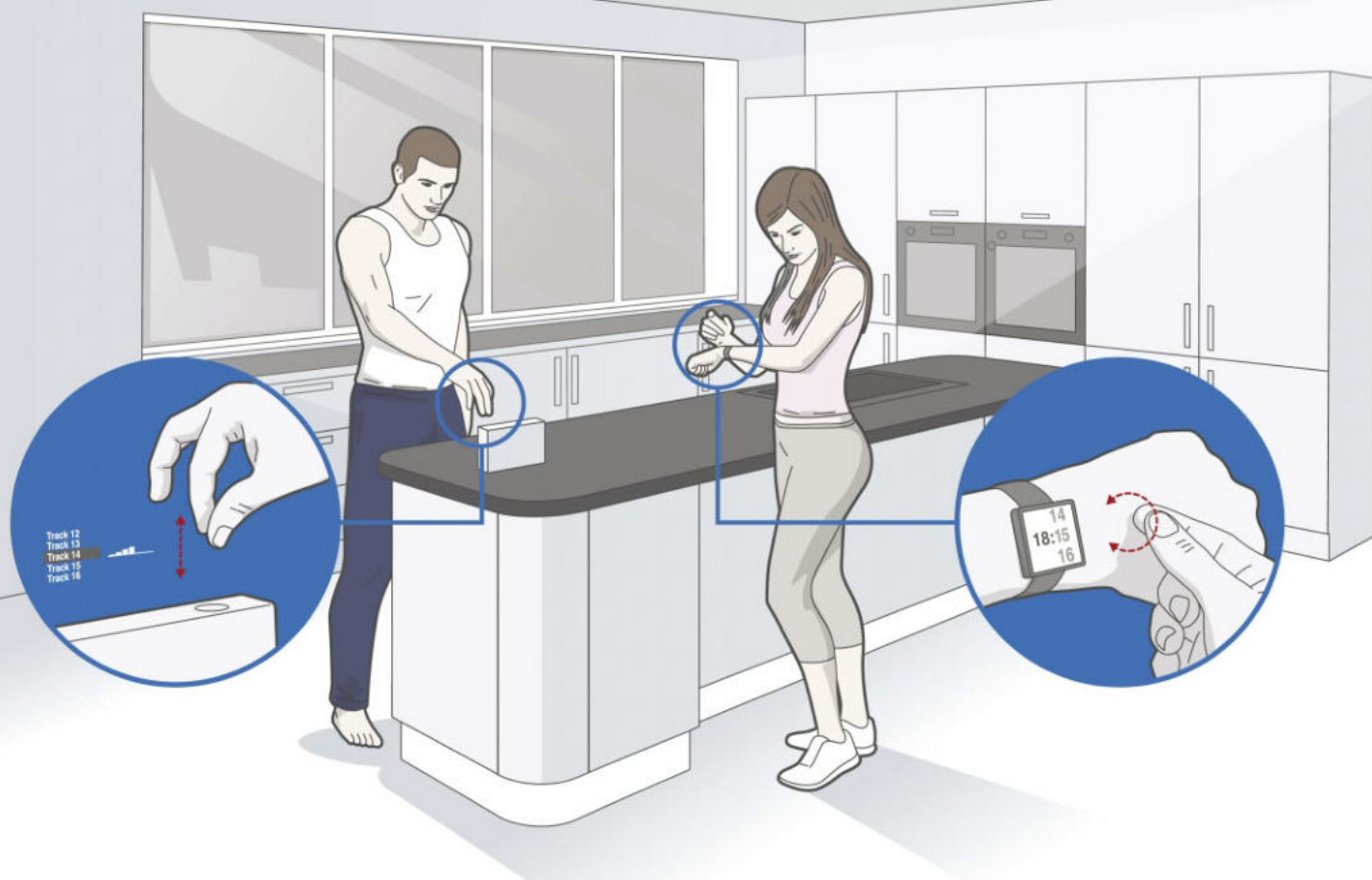
GOOGLE'S ADVANCED TECHNOLOGY and Projects (ATAP) division specialises in creating futuristic technology, such as interactive clothing and an open source modular smartphone platform. One of its most recent prototypes, Project Soli, allows the control of electronic devices without touch. So instead of stabbing away at your tablet or smartphone with your chubby mitts, you make elegant hand movements in mid-air that are translated into commands. Want to turn up the volume? Just twiddle your fingers. Need to turn a page? Simply swipe your hand.

Project Soli has taken shoebox-sized radar hardware and has shrunk it right down so that it can be embedded on a chip. German manufacturer Infineon is working with Project Soli to develop the chips.

The radar transmits a wave towards a target, such as your hand. The radar receiver then intercepts the energy that reflects back. A lot of information can be interpreted from one radar signal because of the gesture recognition system that has been built by Project Soli. Unlike camera-based systems from companies like Leap Motion, Soli needs

no additional hardware and its radar signals are capable of penetrating other materials. This means that even if the chips are embedded inside objects, they can still accurately detect hand gestures. The sensors are incredibly accurate and capable of capturing motion at 10,000 frames per second from as far as a metre away. As the device is so small, it can be incorporated into a range of electronic gadgets and wearables.

Google's Project Soli is ready for mass production and will be released to developers later in 2015.



Google's Project Soli allows gadgets and wearables to be controlled with hand gestures



There are *Great British Bake Off* spoilers on my News Feed!

Q JIM ROBINSON, CAMBRIDGE

Why are some people always so angry?

A MEDICAL REASONS INCLUDE a hyperactive thyroid, diabetes, cardiovascular disease and dementia. Healthy people may resort to anger because they cannot deal with fear, disappointment, frustration or embarrassment. They want to control the world and cannot, or they feel a failure or worthless and blame others for everything that goes wrong. All of this may have roots in past trauma or in poor parenting that leaves children ill-equipped to understand and cope with their own and others' varying emotional states. Anger often harms the angry person more than anyone else. There's no quick fix, but a good start is to recognise your own anger and establish what triggers it as soon as it begins. **SB**

In Numbers

15.72m

is the length of the largest walking robot in the world. It is designed to look like a dragon and can even breathe fire!

Q LIAM FARMER, BIRMINGHAM

Could a dinosaur survive in today's climate conditions?

A IT'S DOUBTFUL. DESPITE what *Jurassic Park* would have you believe, *Tyrannosaurus rex* and *Triceratops* lived in the Cretaceous Period. This ended 66 million years ago. The average global temperature at the time was about 4°C higher than today, with much less difference between the temperature at the Equator and the poles. The sea temperature averaged 37°C, so even tropical seas today would be too cold for marine life of the time. But land dinosaurs would be quite comfortable with the climate of tropical and semi-



"Need... my... inhaler..."

tropical parts of the world today. That is, until they all died of altitude sickness. Studies of air bubbles trapped in amber show that the atmosphere of the Cretaceous may have had up to 35 per cent oxygen, compared to today's 21 per cent. For *T. rex*, this would feel like being at the base camp of Everest. In such thin air, dinosaurs would be too breathless to chase hapless tourists. **LV**

Q ROGER COLLISON, HOLMFIRTH

How does a small bird such as a robin produce such a loud sound?



"Hey you, #&%!&%!
Get off my tree!"

A MALE BIRDS USE their songs to advertise for mates and to warn rival males away from the territory they control. Natural selection favours birds that can broadcast over a wider area and so they have evolved powerful diaphragm muscles. But they use other strategies to make

themselves heard as well. Research at the University of St Andrews has found that as traffic gets louder, birds sing at higher frequencies, which aren't affected so much by the low rumble of passing lorries. And robins in cities sing more at night time too, to avoid the rush hour noise. **LV**

Q AARON COTTINGHAM, CHIDDINGLY

Could alien life breathe a gas other than oxygen?

A FREE OXYGEN IS so reactive that it doesn't last long in the atmosphere unless it is continuously replenished by plants and other photosynthetic organisms. This means that on any planet, including Earth, life must initially evolve without any oxygen to breathe. There are lots of modern bacteria species that 'breathe' other elements and compounds, including sulphur, carbon dioxide, iron, manganese, cobalt and uranium. All of these substances are much less common in the Universe than oxygen, which is the third most common element. There are bacteria that can metabolise hydrogen gas, which is the most abundant element, but like all of these alternative metabolisms, it is much less efficient than oxygen-based



systems. This might mean that simple bacterial life that uses lots of different biochemical techniques is common across the Galaxy, but complex multicellular life only evolves where it has access to the boost in energy provided by oxygen reactions. **LV**

Q BOB BULLOCK, SWANSEA

What are the small bubbles that form in a glass of water?

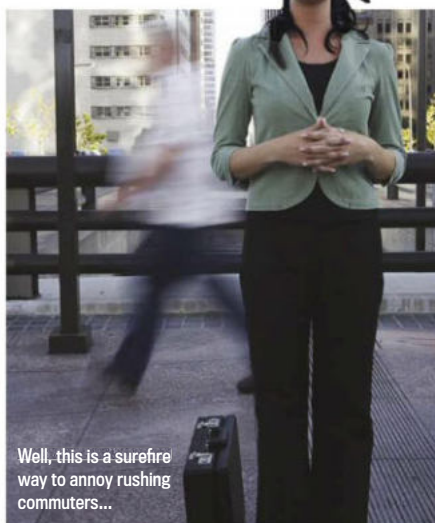
A WATER CONTAINS dissolved gases. When a glass of water is left to stand, the molecules come out of solution and accumulate around small imperfections on the glass. This process of 'nucleation' continues until a bubble forms, breaks free and rises to the surface. Dropping a lemon pip into fizzy water can trigger repeated cycles of nucleation and bubble formation, making it rise and fall repeatedly. **RM**



Q JACK O'NEILL, GLASGOW

What happens if you fire a gun in space?

A ASSUMING YOU ARE floating freely in space, the gun will work just as it does on Earth. Modern ammo contains an oxidising agent to trigger the explosion, so a gun will still fire, despite the lack of oxygen. However, the bullet will continue moving for thousands of years, eventually coming to a stop due to the friction from the diffuse material found in 'empty' space (or when it encounters another object). You will also begin to move, in the opposite direction to the bullet, at a velocity of several centimetres per second. **AG**



Q SUSIE O'BRIEN, LONDON

Is mindfulness good for you?

A GENERALLY, YES, BUT not always and not for everyone. Derived from Buddhist teachings, mindfulness means paying steady attention to the present moment without letting your mind wander into fantasies, fears or

planning. You can practise mindfulness in meditation or in the midst of ordinary life. The Mindfulness-Based Stress Reduction programme claims to decrease anxiety and depression, and increase concentration and wellbeing, with remarkable results reported from prisons, schools, homes and workplaces. Yet many experiments lack proper control groups and few have looked seriously at negative effects. Being mindful is extremely hard at first, because trying to clear your mind means facing up to all those unwanted thoughts and fears. This can be painful and disturbing, so some people feel a lot worse before finding the benefits of self-knowledge and a calmer mind. Stress hormones can increase even when people say they feel more relaxed, and psychiatrists have warned of troubling side-effects including a changing sense of self, depersonalisation, and floods of traumatic memories. A good mindfulness teacher can make all the difference. **SB**

NEXT MONTH Over 20 more of your questions answered



For even more answers to the most puzzling questions, see the Q&A archive at www.sciencefocus.com/qanda

THE GREAT BRITISH
BAKE OFF™

THE SCIENCE OF SOGGY BOTTOMS

Q&A SPECIAL

The Great British Bake Off is now back on our screens. And if you understand the chemistry behind your cakes, you'll have perfect results every time

What happens when cream is whipped?

A CREAM CONTAINS WATER, milk sugars, a small amount of protein and lots of fat. When cream is whipped, small air bubbles become trapped in the mixture. Meanwhile, the fat, which exists as fairly stable droplets inside a cream carton, begins to break up when whizzed around with a whisk. As the fat droplets break apart, molecules of fat rearrange themselves around the air bubbles. As the

air can't escape from the fat, the cream starts to increase in volume until it becomes stiff enough to spread over cakes and pies.

TIP: You should stop whipping cream when it forms stiff peaks – if you carry on, the fat breaks up even further, the air bubbles collapse, and you're on the way to making butter.



Why do biscuits go soft?

A UNLIKE BREAD AND cakes, which tend to become hard the longer they spend in the air, most biscuits go soft. Biscuits are baked to have a low moisture content, which gives them their crunchy texture. When biscuits aren't quickly scoffed, they

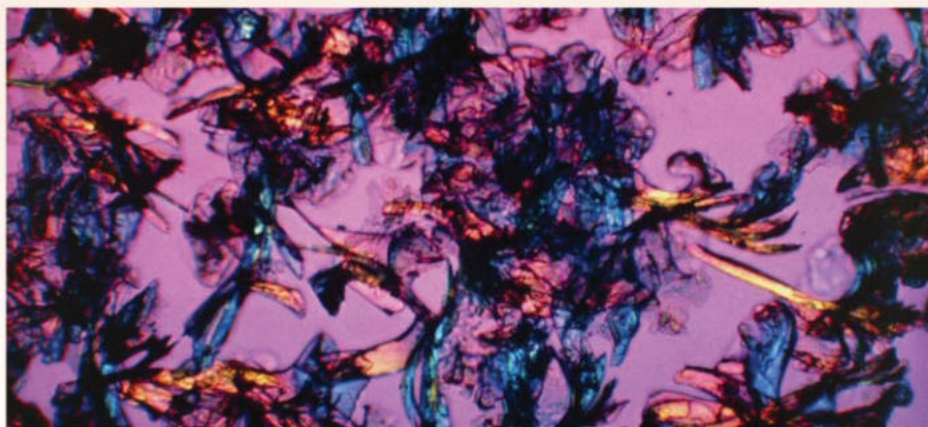
start to absorb moisture from the air, making them go soft.

TIP: Biscuits should be kept in a dry environment to reduce the amount of water absorbed.

Does chocolate make you happy?

A A 1996 STUDY showed that chocolate caused the release of endorphins in the brains of American women, making them feel happy. Chocolate contains a number of compounds associated with mood-lifting chemicals in the brain. Frequently mentioned are phenylethylamine, a natural antidepressant, and tryptophan, which is linked to the production of serotonin – a neurotransmitter associated with happiness. A handful of other substances also add to chocolate's

purported effects. Theobromine can increase heart rate, and caffeine is known as a 'wake-up' drug. But most of these compounds are present only in tiny quantities in chocolate, and some scientists say that they are probably almost entirely digested before they reach the brain. It may instead be the experience of eating chocolate, and satisfying a food craving, that releases endorphins and 'happy feelings' more than the content of the chocolate itself.



Tryptophan is an amino acid that's linked to serotonin production

Can baking improve your mental health?

A JOHN WHAITE, WINNER of 2012's *The Great British Bake Off*, published a recipe book explaining how baking helped him cope with depression. Creativity, goal-orientated behaviour and focused attention are all central to baking, and are associated with positivity and a sense of accomplishment. Other potential benefits come from engaging less-used senses – particularly touch, taste and smell – and from the rewarding feeling of making something that can be shared. However, most of the evidence for the link with mental health is anecdotal. A small 2004 study in the *British Journal Of Occupational Therapy* suggested that baking classes boosted confidence in a group of inpatients in mental health clinics, but more research still needs to be carried out.



John Whaite claims that baking helped him cope with depression

Heaviest slab of fudge

Record: 2.61 tonnes
Location: Levack, Ontario, Canada
Year: 2010
Notes: The fudge took one week to make and was flavoured with vanilla, chocolate and maple





Flimsy baking equipment can lead to soggy pastry

Why do pies get a soggy bottom?

A THE MAIN INGREDIENTS in pastry are flour and fat. The gluten in the flour gives pastry its texture, while fat offers flavour. If the fat melts before a strong gluten structure has formed, the pastry will end up soggy. Overly moist fillings can also contribute to a soggy bottom as the liquid will drop to the bottom of the pie and ooze into the pastry. To ensure crisp pastry, the base can be blind baked

before adding the filling. Alternatively, fillings should be cooled before adding to the pastry to cut down on the amount of steam, and therefore moisture, that's produced. Cutting large slits into the lid of the pie ensures that steam can escape.

TIP: Sturdy, good-quality tins heat faster than flimsy ones and retain higher temperatures, which keeps pastry crisp.

Oldest cake

Record: 117 years old
Year: 1898

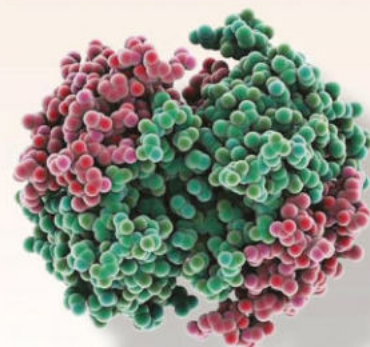
Location: Willis Museum, Basingstoke
Notes: It has a large crack due to a WWII bomb blast. It has recently been treated with silicon gel to increase its lifespan



What gives meringue its unique structure?

A MERINGUE CONTAINS EGG white, which is a mixture of proteins and water. Air whisked into the egg white becomes trapped and surrounded by a network of proteins. Adding sugar after the eggs have been whisked stabilises this protein network. When the meringue is cooked, water in the egg white evaporates, the air bubbles expand and the protein network is solidified, forming a light, crisp structure.

TIP: Meringue mustn't be cooked too quickly or at a high heat, because if the sugar cooks before the water has had time to evaporate, you'll end up with a brown meringue with a soggy middle.



Molecular model of the protein in egg white

To keep apples looking fresh, damage their enzymes



Why do apples turn brown so quickly?

A WHEN YOU SLICE into an apple, air reaches the inner part of the fruit. Once exposed to oxygen, enzymes in the apple begin converting natural chemicals called polyphenols into brown melanin compounds. This year, the US government approved a genetically modified apple variety that can't produce the browning enzyme. They can be sliced and diced without losing their fresh appearance.

TIP: To prevent browning, place apple slices under water to starve the enzyme of oxygen, or damage the enzyme by adding lemon juice to the cut surface.

Why does bread go stale?

A STALING IS OFTEN attributed to a loss of moisture from bread. But on a microscopic scale, there's a lot more going on. The flour used to make bread contains high quantities of starch molecules. In their natural state, these form a crystalline, highly organised structure. Adding water to the flour undoes this structure, allowing the starch molecules to take on a more disorganised, gel-like arrangement that gives bread a soft, fluffy texture when it comes out of the oven. As bread starts

to cool, water leaves the starch and moves into other parts of the mixture, allowing starch molecules to return to their crystallised state. It's this recrystallisation – not drying – that makes bread go hard, and it happens even in humid conditions. Keeping bread in the fridge doesn't help. In fact, recrystallisation happens faster at cooler temperatures. Freezing, however, dramatically slows the process, which is why bread can be successfully stored in a freezer.



Longest baguette

Record: 111m

Year: 2009

Location: Ho Chi Minh City, Vietnam

Notes: The baguette was cooked in a 120m oven and took 11 minutes to bake



This image of bread was taken using a microscope and shows starch (brown), fat (purple) and the gluten network (red)



ENJOY A GREAT DAY OUT

RadioTimes FESTIVAL

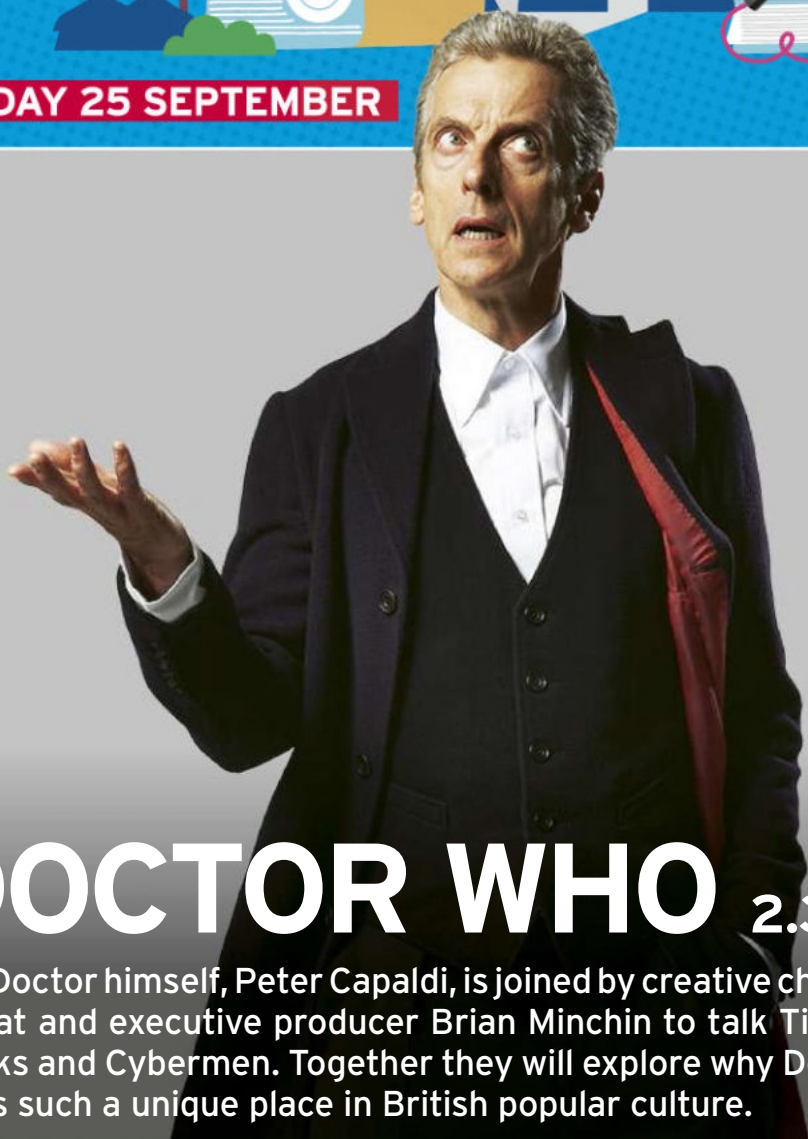
TELEVISION | RADIO | BOOKS

Buy tickets
to three events
AND SAVE
10%*
Quote SAN to get
your discount

Choose
from
OVER 70
TV & radio
events



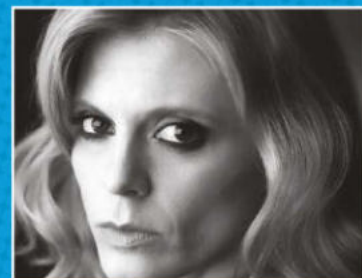
FRIDAY 25 SEPTEMBER



DOCTOR WHO 2.30PM

The Doctor himself, Peter Capaldi, is joined by creative chief Steven Moffat and executive producer Brian Minchin to talk Time Lords, Daleks and Cybermen. Together they will explore why Doctor Who holds such a unique place in British popular culture.

COMPANY PRODUCTIONS LTD



SILENT WITNESS, 7PM

As Silent Witness approaches its 20th anniversary, key figures from the show take us inside the pathologist's laboratory. Emilia Fox and forensic pathology adviser Dr Stuart Hamilton show you how to catch a killer.



THE SCIENTIFIC SECRETS OF DOCTOR WHO, 5.30PM

Join Simon Guerrier and Dr Marek Kukula, authors of The Scientific Secrets of Doctor Who, as they explore the possibilities of time travel, life on other planets, artificial intelligence, parallel universes and much more.

To book tickets and for the latest festival line-up visit
radiotimesfestival.com or call **0871 2305 539****

THE GREEN AT HAMPTON COURT PALACE 24-27 SEPTEMBER

* APPLIES TO ADULT SESSIONS ONLY ** CALLS COST 10 PENCE PER MINUTE PLUS STANDARD NETWORK CHARGES

THE FUTURE OF GADGETS

TECH HUB

EDITED BY **RUSSELL DEEKS**

THIS MONTH

APPLIANCES OF SCIENCE

A wooden smartwatch, radar bicycle lights, a Braille tablet and more p83

ULTIMATE TEST

Top tech to see you through university p84



ON THE HORIZON

MICRO MACHINE

A tiny new computer aims to kick-start Generation Code

techwillsaveus.com/microbit

BACK IN 1981, the BBC and Acorn computing launched the BBC Micro, a microcomputer that was sold to UK schools at subsidised prices. Along with the Commodore 64 and ZX Spectrum, the soon-ubiquitous BBC Micro helped inspire a generation, leading to the growth of a thriving British computer games and software industry. “The Beeb introduced a generation of British children to the power

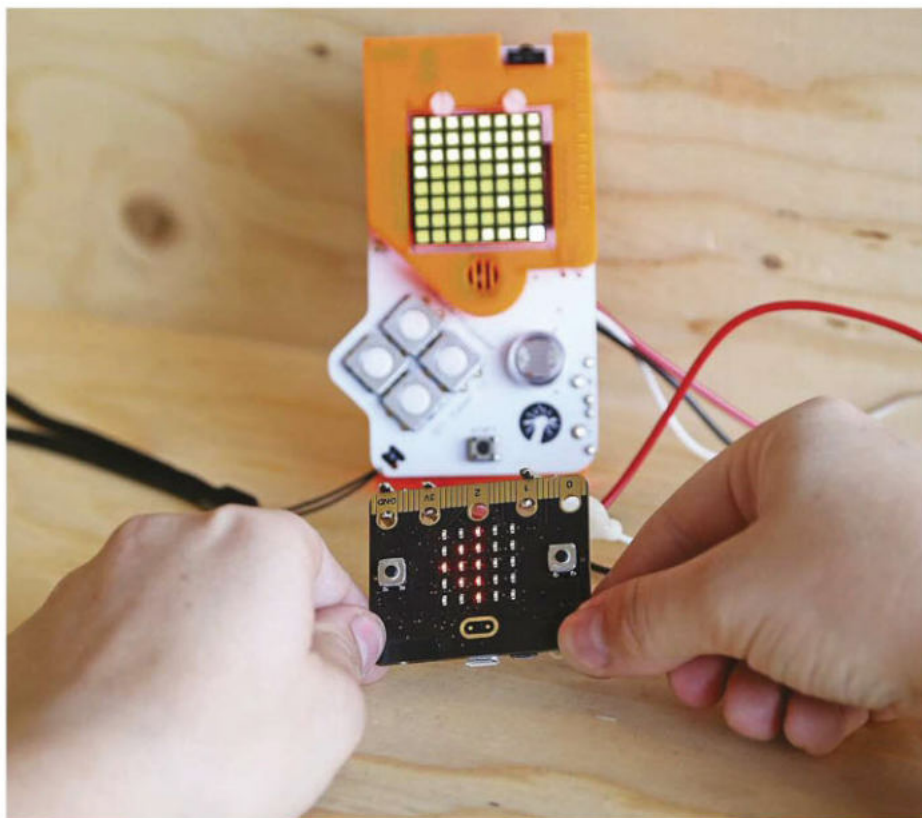
of programming,” Wolfram Research’s Conrad Wolfram said in 2011, while Codemasters co-founder David Darling described it as “central to the whole [8-bit] revolution”.

Now, 34 years on, the BBC is looking to repeat the trick again with the BBC micro:bit. This Raspberry Pi-like device will be given to every Year 7 student (11- and 12-year-olds) this October, with the aim to get an entire generation interested in computer coding.

“We happily give children paintbrushes when they’re young, with no experience. It should be the same with technology,” states Sinead Rocks, Head of BBC Learning, which is the division that masterminded the project. “The BBC micro:bit is all about young people learning to express themselves digitally.”

The BBC micro:bit has been created with the assistance of 29 industry partners, including the likes of Microsoft,





The BBC micro:bit is a pocket-sized computer that can be hooked up to other devices

➔ Samsung and the Wellcome Trust, and aims to address a concern often voiced by employers: namely, that current IT teaching produces school-leavers who know how to use computers, but have very little idea how they actually work. Accordingly, the micro:bit has been designed as a 'blank canvas', a tool that budding engineers can use to build whatever they want.

It's essentially a printed circuit board that measures 5cm by 4cm and weighs 8g. Mounted on the board are 25 red LEDs in a 5x5 matrix, two programmable buttons, a three-axis accelerometer, a compass, a Bluetooth chip, three connectors that will accept crocodile clips or banana plugs, a 20-pin edge connector and a micro-USB controller. It can connect to a wide range of sensors, and to other similar devices such as the Raspberry Pi or the Arduino One. Early prototypes also featured a slot for a watch battery, but this has since been removed for safety reasons; anyone wishing to use the micro:bit to create a wearable device will need to add a AAA battery pack.

That's the hardware side of things. The micro:bit also comes with its own web-based, multi-platform editing and programming environment. Using a desktop computer, tablet or smartphone,

users can write programs for the micro:bit in any of several languages, including C++, Javascript, Python and Blocks. They can then upload them to the micro:bit server, which will send back compiled code that the user simply drags and drops to their micro:bit.

A large number of uses for the micro:bit have already been suggested, including using it as a controller for a DVD player, building a metal detector or spirit level or, for the more ambitious, making it the heart of an Internet of Things-connected device. Indeed, the latter seems to be something of a mission objective, with Rocks saying, "As the micro:bit is able to connect to everything from mobile phones to plant pots and Raspberry Pis, this could be for the Internet of Things what the BBC Micro was to the British gaming industry."

With one of these devices about to be put in the hands of youngsters across the nation, who knows what uses they'll come up with for them? And if you're not aged 11 or 12, there's no need to feel left out – a consumer model of the micro:bit is set to go on sale in various outlets before the end of the year.

RUSSELL DEEKS is a freelance science and technology journalist

TECHOMETER

WHAT'S HOT

RETRO GAMING

Commodore is about to launch a smartphone. Named PET after the company's original game-changing computer, the Android device will have emulators that let you play old C64 and Amiga games. Spectrum fans, meanwhile, will soon be able to get their hands on the ZX Vega, a £100 emulator with 1,000 vintage games built in.



WHAT'S NOT

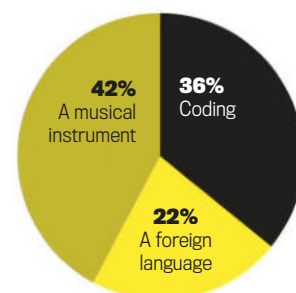
AIBO

Sony's robot dog caused a sensation when it launched back in 1999. But Sony cancelled the line in 2006, and announced last summer it would no longer be repairing them – with the result that some Buddhist priests in Japan are now offering AIBO cremations so that distraught owners can see their robotic loved ones off in style.



READER POLL

Which would you prefer your child to learn?



THE NEXT BIG THING

TOTAL IMMERSION

Cinemas are about to get interesting

PREVIOUSLY, I WAS the online editor for the Cambridge Film Festival. I'm still a big fan of watching a great film in a fine cinema with an engaged audience – dark rooms with good sound systems are a fabulous forum for shared experiences. But just when cinema looked like it had managed to cope with the advent of television and the growth of smaller and more portable screens, it has to cope with the next big thing – immersive video.

The rapid development of augmented/virtual reality headsets is changing the rules. They offer new ways to tell stories, along with a compelling experience that could challenge cinema viewing.

Virtual reality headsets have been around for a while. Oculus Rift, one of the main developers, is now owned by Facebook, while Microsoft has announced its HoloLens system. Samsung Gear VR uses a smartphone as its display, and Google has developed Google Cardboard, which can turn your smartphone into a passable VR viewer.

Earlier this year, the award for the best interactive

documentary at Sheffield Doc/Fest, one of the major documentary film festivals in the world, went to *Clouds Over Sidra*. This short immersive film about the life of a 12-year-old girl was filmed in a refugee camp near the Syrian border. This documentary would have been interesting enough on a TV screen, but it became truly compelling when you could turn your head to see the camp stretching to the horizon, or the baker making cakes on the range in the corner of the tent.

The BBC is already experimenting with the 360° format for news reports. The emotional impact can be immense – the effect of seeing a bomb attack in Nonny de la Peña's *Project Syria* is far greater than watching it on TV. However, the new technology is very different from using a single camera and it will require new ways of working, new ethical frameworks and simpler tools for capturing and editing. One important issue is where to put the crew – when filming with 360° the viewer can see where your sound man is standing!

At the moment the experience is an individual one, with each of us seeing the scene



Cinemas that use virtual reality could offer a truly immersive experience

on our own. But Microsoft has already worked with NASA to link together users of its HoloLens system so they can work collaboratively on images of the Martian surface. Meanwhile, innovative developers are working on ways to use headsets to provide a communal experience somewhere between cinema and actually being there.

We are starting to see what cyberspace might really look

like, and it's pretty exciting. Of course, I'm really waiting for us to start connecting our visual systems to our computers without the clumsy screens getting in the way, but that's not going to happen just yet.



BILL THOMPSON contributes to news.bbc.co.uk and the BBC World Service

FROM THE LAB SMART HEADLIGHTS THAT READ THE ROAD

WHAT IS IT?

Ford's Camera-Based Advanced Front Lighting System is being developed at the car maker's Research & Innovation Centre in Aachen, Germany. The manufacturer's system builds upon current 'smart' features to produce headlights that can self-adjust, enhancing the headlights when approaching hazards such as animals in the road, bends or junctions.

HOW DOES IT WORK?

An infrared camera in the car's front grille detects body heat from people or animals up to 120m away, then two independent spotlights illuminate them. The system also incorporates GPS, which monitors your whereabouts and boosts your headlights at blind bends or junctions. When there's no GPS signal, the camera can track road markings by 'reading' traffic signs.

WHEN WILL IT BE IN ACTUAL CARS?

Ford says that "we expect this technology to be available for customers in the near term", but has not given any definite timeline as yet. For those *Focus* readers who are not au fait with motor vehicle industry terminology, "the near term" is around the same length as a piece of string... so we'll just have to keep our eyes peeled.



A display in the car outlines hazards in either yellow or red, depending on the level of risk

WI-FI

Finally in any room*



- ✓ Better than any Wi-Fi repeater
- ✓ Enjoy Wi-Fi in any room*
- ✓ Best reception for smartphones and tablets



dLAN® 500 WiFi Starter Kit

- Unpack, plug in, get started
- Improves Wi-Fi reception and range
- Engineered in Germany
- 3-year manufacturer's warranty

* Required: broadband Internet connection, router and active power sockets within one property.

amazon.co.uk

The electronics specialist
maplin

currys

PC World



More information:
www.devolo.co.uk/wi-fi
Tel.: +44 (0)1865 784344
Email: sales@devolo.co.uk

devolo

The Network Innovation



APPLIANCES OF SCIENCE

1 REAR-VIEW RADAR

Around 40 per cent of cycling fatalities occur when a bicycle gets hit from behind. Reduce your chances of that happening with Garmin's high-tech rear-light radar. The Varia detects vehicles approaching from as far as 140m behind you. It then relays the proximity info to you via a small handlebar unit. The rear light will also start increasing in brightness, alerting the drivers to your presence.

Garmin Varia Rearview Bike Radar
£240, garmin.com

2 TIMBER TIMEPIECE

The smartwatch gets a makeover in the form of the Kisai Blade Wood Link Watch from TokyoFlash, which pairs with your iOS device via Bluetooth. The wooden face conceals red or green LEDs that reveal the date and time, while icons on the strap will light up whenever you receive a call, text or email. There's a 'find phone' function for forgetful types, but note that you'll need to be running iOS 8.1.2 or above to use it.

Kisai Blade
£101.25, tokyoflash.com

3 TOUCH TABLET

There are 285 million blind or visually impaired individuals worldwide, which is a lot of people to shut out of the 'tablet revolution'. Enter BLITAB, a tablet that creates Braille out of tiny, liquid-filled bubbles. Up to 15 lines of Braille can be displayed, while built-in software can convert text into Braille from websites, USB sticks or NFC tags. BLITAB can display graphs, pictures and maps. It is expected to go on sale in 2016.

BLITAB
Price TBC, blitab.com

4 DIVING DRONE

Fancy yourself as the next Jacques Cousteau? Then this underwater drone built to carry a GoPro camera should be right up your, er, inlet. Measuring 774 x 285 x 290mm, it shoots images and can stream live video to either your phone or an optional controller so you can steer it from dry land. The freshwater model is available now, with a saltwater version due later this year.

TT Robotix SEAWOLF
\$999 (£645 approx), ttrobotix.com

5 BUDGET BURNER

Want a 4G smartphone running the latest version of Android? How does £49 sound? That's the price of this budget model from EE, which aims to bring 4G tech within the reach of 2.5 million UK pay-as-you-go customers. Naturally, there are compromises: screen resolution is just 480 x 800 pixels and there's only 1GB of memory. But as a phone to give the kids or take to festivals, the Rook is definitely worth a look.

EE Rook
£49, ee.com

6 TRIASSIC TEACHER

With Siri/Cortana-like 'digital assistants' becoming increasingly common, it was only a matter of time before a kids' version emerged... and here it is, in the form of a cute green dinosaur with the slightly prosaic name of Dino. Dino will answer questions, adjusting content based on how the toy is used. It's updated constantly via its accompanying app, so expect new features to be added over time.

Cognitoys Dino
\$119.99 (£77.25 approx), cognitoys.com

 ULTIMATE TEST

BACK TO SCHOOL

The summer holidays are nearly over, so here's our pick of the top tech for the start of term.

Sam Kiildsen reports

1. APPLE MACBOOK AIR

From £750, apple.com/uk

Still the undisputed king of thin, light laptops, the MacBook Air doesn't offer all the bells, whistles and sheer processing grunt of a MacBook Pro. Nonetheless, it handles almost everything a student could throw at it more than adequately, while being eminently user-friendly and reliable. The battery lasts up to 12 hours in the 13-inch version, while its 11-inch little brother offers nine hours of life, so it's very unlikely to conk out on you when you need it most.

2. ACER CHROMEBOOK 15

£230, acer.co.uk

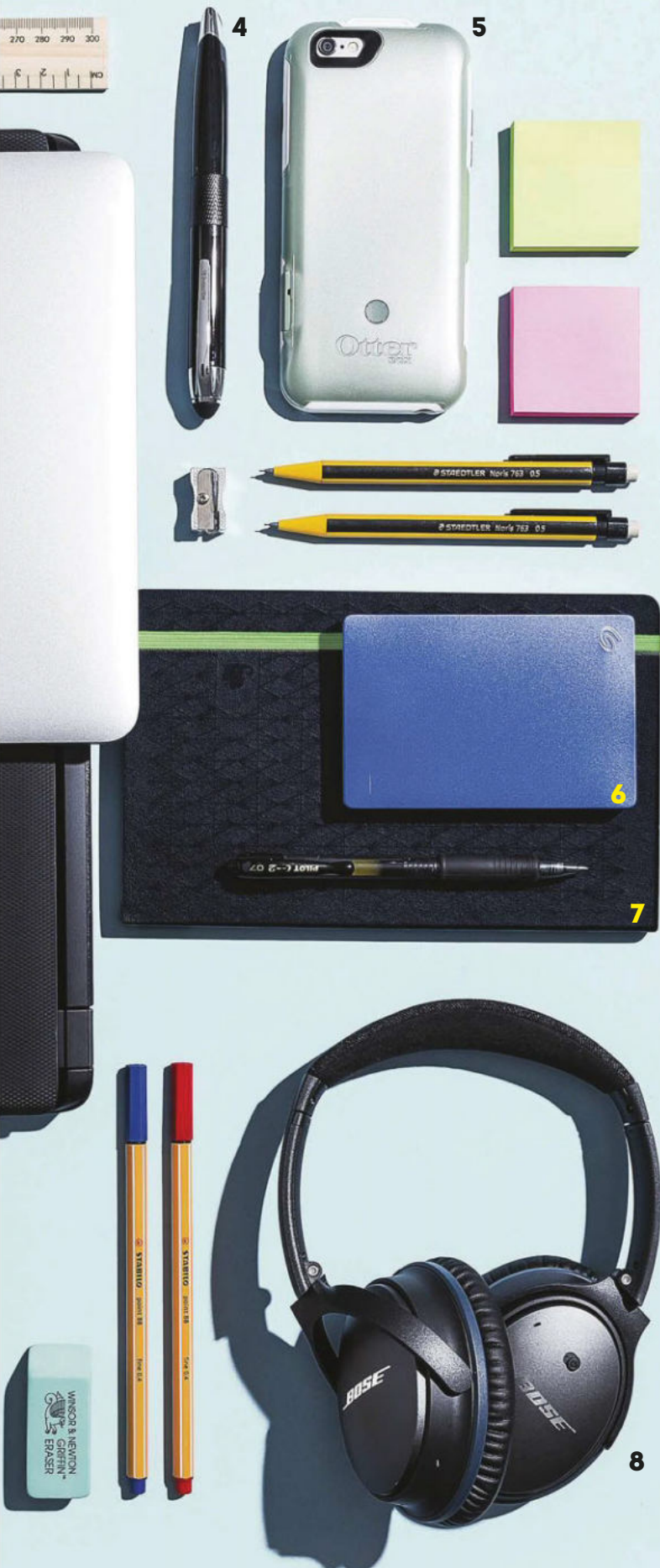
Pictured here is the model C910, and if you're operating on a tight budget, this 15.6-inch notebook makes for a great working companion. It's not the thinnest or lightest laptop around, but it's a lot speedier than comparable Chromebooks and offers almost nine hours of battery life. Everything you work on will be automatically stored in the cloud (Google offers 1TB of free cloud storage), so there's almost no danger of that precious essay going walkies – even if the laptop itself does.

3. KINDLE PAPERWHITE

From £110, amazon.co.uk

Amazon's Kindle e-reader has been around for several years now, so you're probably already aware that this device will let you carry round the entire works of Shakespeare and much, much more besides in your jacket pocket. But this new model ups the advantages with a backlit screen so sharp it looks like printed paper, six weeks of battery life and a built-in notetaker. Meanwhile, the X-Ray feature delivers useful background information on relevant historical events, characters and other points of interest.





4. LIVESCRIBE 3 SMARTPEN

£130, livescribe.com/uk

Prefer to write your lecture notes by hand rather than tapping them into a tablet or laptop? Then the Livescribe 3 smartpen could help you bridge the gap between the analogue and digital worlds. Any handwriting or sketches jotted on the company's special paper can be swiftly digitised by the pen's scanner and then transferred in pristine digital form to an iOS or Android device via Bluetooth. Hey presto – no need to leaf through endless notepads trying to find a particular note. Although it does spell an end to the excitement of buying highlighters and Post-it notes at the beginning of term...

5. OTTERBOX RESURGENCE

£90, otterbox.co.uk

We've all been there: after a long day, your smartphone's battery has expired when you need it most. With the Resurgence case from OtterBox, that's very unlikely to be the case (no pun intended). As well as offering military-grade protection for your iPhone 5, 5s or 6 from drop damage, its own internal battery doubles the device's power supply. And all while keeping the phone slim enough to remain pocket-sized. It even comes in a choice of two colours for the iPhone 5 and 5s, and four for the iPhone 6.

6. SEAGATE BACKUP PLUS SLIM

£85, seagate.com

Chances are you'll be working with data in some capacity during your studies, and this portable hard disk drive is just about the slimmest, toughest, and most reliable option out there. Weighing just 159g and protected by a sturdy metal body, it offers a speedy USB 3.0 connector and a cavernous 2TB of storage – enough for 620,000 photos, 500,000 songs or 1,000 hours of digital video. As a bonus, there's 200GB of free cloud storage through Microsoft's OneDrive thrown in.

7. MOLESKINE EVERNOTE

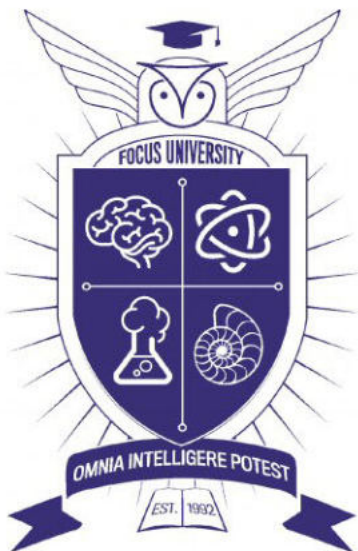
£11.50, amazon.co.uk

This stylish Moleskine notebook is another innovative product that straddles the analogue and digital world, and has been designed in collaboration with the Evernote cloud service. Make notes or drawings on the notebook's pages, then use your iOS or Android phone's camera to capture them and they'll be integrated straight into Evernote. You can even use stickers to ensure these captured notes are tagged and immediately put into the correct place. It comes with three months' free subscription to Evernote Premium.

8. BOSE QUIETCOMFORT 25

£270, bose.co.uk

Sometimes it can be difficult to find a peaceful spot to work in, but with these Bose headphones you can simply create your own quiet place. They feature superb noise-cancelling technology that dramatically reduces external sounds. It won't totally silence everything, but it is especially proficient at deadening mechanical hums like engines, air conditioners or fans. Sound quality is also excellent, so when you actually do want to hear something the QuietComfort 25s don't disappoint.



DNA

IN 10 MINUTES

We established DNA's structure in the 1950s. Since then, we've cloned animals and mapped the human genome. **Tom Ireland** deciphers the code that is key to understanding life

What is DNA?

In 1953, two biochemists, James Watson and Francis Crick, walked into a pub in Cambridge and declared: "We have discovered the secret of life!"

They weren't exaggerating. They had worked out the structure of DNA, and with it, unlocked many of the mysteries of how living things make and replicate themselves.

DNA, or to use its full name, deoxyribonucleic acid, is found at the heart of every cell of every living thing. It carries all of the instructions for an organism to build, maintain and repair itself. By replicating and passing on their DNA, animals, plants and microorganisms can impart their characteristics to their offspring.

In humans, half the DNA in our cells stems from our mother, and half from our father. This is why we inherit a mixture of characteristics from both parents. DNA is a hugely long and complex code, and everyone's is unique. This 'genetic code' can tell us many things, including details about ancestry and potential health problems.

Our understanding of DNA has revolutionised the whole of biology. It has allowed scientists to measure how closely organisms are related to one other, helping to both confirm and refine Charles Darwin's theory of evolution.

How does DNA work?

Establishing the structure of the DNA molecule was key to figuring out how it worked. Before that, scientists had no idea how this

dense, stringy substance controlled qualities as diverse as human hair colour, or the shape of a bird's beak.

Watson and Crick found that a DNA molecule is arranged like a very long, twisted ladder in a structure we call a double helix. Each 'rung' of the ladder is made up of a base pair – two joined chemical building blocks called nucleotides. There are four different types of these nucleotides: adenine, cytosine, guanine and thymine. We call these A, C, G and T. An A nucleotide always links to a T, while a C always links to a G. The exact order that the letters are arranged on the ladder varies, forming an enormously long code. Human DNA has about three billion 'rungs on the ladder'.

With modern technology we can extract DNA from cells and decipher the exact order of the base pairs, giving us an extraordinarily long string of letters A, C, T and G. This complex code will be different for every person and every organism (apart from identical twins), and is known as our DNA sequence or genome.



Francis Crick (left) and James Watson shortly after discovering DNA's structure in 1953

PHOTO: GETTY, SCIENCE PHOTO LIBRARY



What
is this

?

This is a DNA molecule, showing its famous double helix structure. The 'backbone' of the DNA is made from sugar and phosphate. DNA's full name, deoxyribonucleic acid, offers a clue to the sugar present: deoxyribose. Base pairs make up the 'rungs' of the DNA molecule. Each of the base pairs consists of two joined nucleotides.

TIMELINE

Gregor Mendel (pictured) establishes the basic rules of inheritance. Friedrich Miescher isolates DNA, a substance he calls nuclein, from cells found in pus.



1860s

1944



Oswald Avery (pictured), Colin MacLeod and Maclyn McCarty demonstrate that DNA is the material that's controlling inheritance.

James Watson and Francis Crick describe the structure of DNA, deduced using images produced by Raymond Gosling, Rosalind Franklin and Maurice Wilkins.

1953

1972

DNA from two different organisms is spliced together for the first time by Paul Berg, paving the way for genetic modification and GM foods.



1996



Dolly (pictured with her lambs) is born. Dolly is the first mammal cloned from a non-embryonic cell. Her DNA is identical to the sheep she was cloned from.

2003

After £3bn and 13 years of work, the Human Genome Project is completed and the entire genome of a human being is published. Today, people can get their genome sequenced in a matter of hours for around £100.



President Barack Obama announced plans to sequence the genomes of one million US citizens to help personalise medicine and learn more about rare diseases.

2015



To understand how DNA works, we must first understand proteins. Protein molecules perform many of the different tasks inside our cells, and help create many of the intricate structures within the body.

There are many different types of protein, but they are all made from long chains of chemical building blocks called amino acids.

The genetic code formed by DNA is like a language, which tells cells how to build the proteins they need. Different three-letter combinations in the DNA represent different types of amino acid – for example, the sequence 'GCA' is the code for an amino acid called alanine, and 'TGT' represents one called cysteine.

Molecular machinery within the cell 'scans' the DNA sequence of a gene. Every three letters, it adds the corresponding amino acid to a chain. There are even sections of DNA that mean 'stop' – the protein is finished.

Different combinations of amino acids create proteins with vastly different functions – from tiny chemical messengers like hormones to the tough, important molecules that form hair, skin and muscle. Proteins can also act as catalysts for important chemical reactions, or can create mini-machines that perform very specific tasks within cells.

There are hundreds of thousands of different proteins in the human body and many, many millions more throughout the natural world. Variation in our genes causes variation in the proteins our cells produce, which in turn leads to differences in characteristics.

What are genes?

Genes are sections of our DNA sequence that contain the code for a specific protein, normally linked to a specific function or physical characteristic. In humans, for example, a stretch of DNA known as 'OCA2' has a strong influence on a person's eye colour.

Variations in these parts of our DNA lead to the different characteristics we see among individuals. For example, people with blue eyes have different DNA at 'OCA2' than people with brown eyes.

A common misconception about genes is that one gene is responsible for one trait, which is actually highly

unusual. More commonly, physical traits result from a combination of many genes. Scientists can study what a gene does by removing it or changing the sequence of base pairs, normally using animals like fruit flies, worms or mice. These 'mutant' animals are then studied to see what is different about them.

How does DNA replicate?

The discovery of DNA's 'double helix' structure helped reveal the beautifully simple way a DNA molecule replicates itself. With the help of other chemicals in the cell, the double helix untwists and the two strands split down the middle, like a zip. Because A always pairs with T, and C with G, both strands then form an exact copy as more nucleotides are attracted into the corresponding place opposite the freshly split strands.

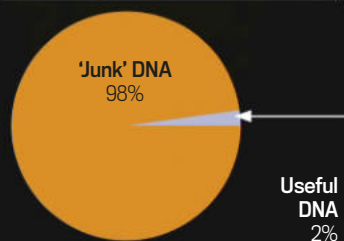


Key evidence

Below left is 'Photo 51'. The image was made in 1952 by Raymond Gosling, a PhD student who was working under the supervision of the English chemist Rosalind Franklin (pictured left). The pattern formed by passing X-rays through a sample of DNA. One year later, Photo 51 helped Francis Crick and James Watson to figure out the double helix structure of DNA. The two scientists, along with Maurice Wilkins, were awarded Nobel Prizes for their discovery in 1962. Franklin died of cancer in 1958, aged 37.

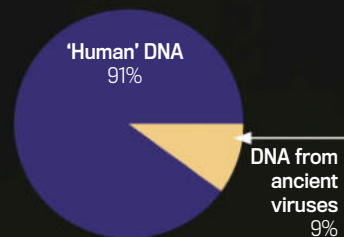
IN NUMBERS

JUNK DNA



Up to 98 per cent of our DNA is 'non-coding' - meaning there are no genes in these sections

VIRUS DNA



Up to 9 per cent of our DNA is thought to be from ancient viruses that have merged with our genome

AMOUNT OF DNA WE SHARE WITH OTHER SPECIES

CAPACITY OF DNA



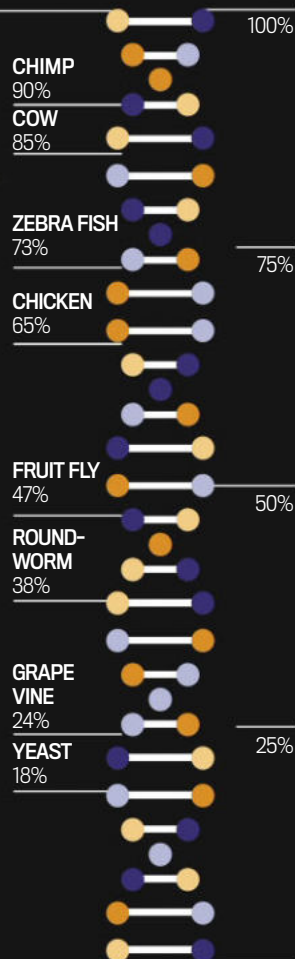
500,000

DVDs' worth of information can be stored in a **single gram of DNA**

SMALLEST GENOME

112,000

nucleotides are present in the bacteria *Nasuia deltocephalinicola* - the smallest genome found so far



JARGON BUSTER

BASE PAIRS

DNA consists of building blocks called nucleotides. There are four different types and each is assigned a letter: A, C, G or T. A always links with T and C always links with G. When connected, these form the base pairs.

DNA SEQUENCING

This is an important technique in biology that allows us to 'read' the sequence of nucleotides.

GENE

A section of DNA that has a particular function. Genes rarely do just one thing and often it is the combination of many genes that result in a physical characteristic like eye colour or height.

You inherit genes from both your mother and your father.

GENOME

This entire DNA sequence of an organism. The human genome was sequenced in 2003. Everyone's genome is unique, but we can tell how closely related we are by studying similarities between genomes.

GENETIC DISORDER

A problem caused by one or more abnormalities in a person's genome, normally present from birth. Most genetic disorders are quite rare.

GENETIC MODIFICATION

Changing the DNA of an organism so that it has different properties. One example would be inserting a gene from one crop into another to make it resistant to pests.

→ This replication process is crucially important, because cells are constantly dividing and replicating. If DNA is copied incorrectly, the resulting cells have jumbled instructions and can start growing out of control. This is often how a cancerous tumour starts.

What are chromosomes?

In animals and plants, the amount of DNA in each cell is so vast that it must be cleverly packaged into x-shaped bundles called chromosomes. These structures coil and fold the DNA so it doesn't take up too much room, while still allowing the cell to access all the important parts of the code. If it weren't wrapped up in chromosomes, scientists think the DNA in one human cell could stretch for more than 1.5m.

In humans, our entire genetic code is spread across 23 chromosomes. We each inherit one set of 23 from our mum, and another set of 23 from our dad, so each cell contains 46 chromosomes. When people are born with too many or too few chromosomes, it can cause health

issues. For instance, people with Down's syndrome have three lots of chromosome 21 instead of a pair.

The sex chromosomes are a little different. One is called X and one is called Y. Males have one copy of each, X and Y, whereas females have two copies of X. When a sperm fuses with an egg, the new cell gets one of every chromosome from each parent. So it will have 23 pairs or 46 chromosomes, with either two X chromosomes (female) or one X and one Y (male).

Different organisms have different numbers of genes and chromosomes in their cells. Mosquitoes have just six chromosomes, while a type of fern known as 'adder's tongue' has over 1,000 – though no one really knows why it needs that many.

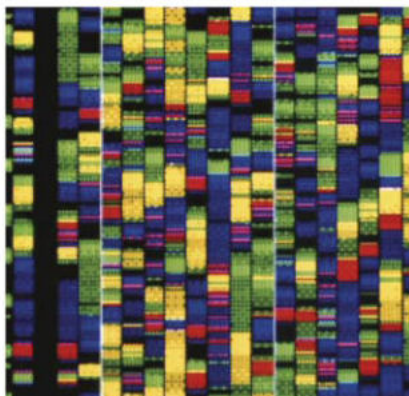
But do our genes determine everything about us? Scientists and philosophers have argued for centuries about whether our lives are controlled by nature or nurture. The simplest way to answer this question is to say that we are a product of a combination of our inherited genes and our environment.

A small number of genes have been linked to certain character traits, such as high intelligence or extreme anti-social behaviour, but the evidence is limited. It is more likely that lots of genes work in combination to influence our personality, and the experiences and events of our lives also shape the way our brains work.

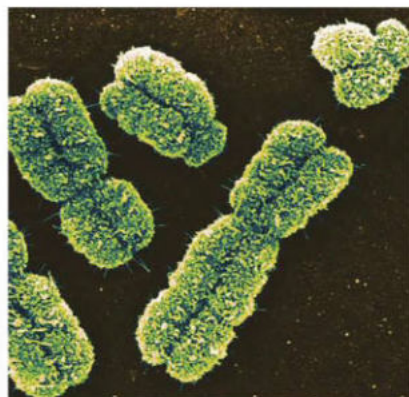
Although every person's DNA sequence is unique, huge sections of it are identical between people and even animals. In fact, about 95 per cent of our genome is the same as a chimpanzee's, while 25 per cent is the same as a grape's.

The amount of genetic variation between individual people is very small – just 0.1 per cent of the three billion base pairs will be different if you compare two people. Yet this variation gives rise to seemingly infinite appearances.

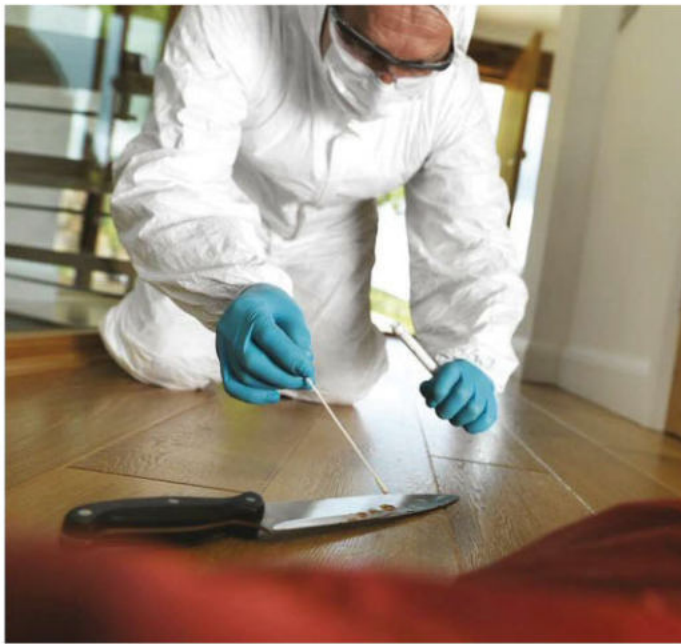
To complicate matters further, the relatively new field of 'epigenetics' is increasingly showing that our genes can be expressed differently – turned on and off – at different times throughout our lives, meaning the way our genes work is even more complex than we first thought.



Human gene code; each colour represents a nucleotide base



To save on space, DNA is coiled up into chromosomes



Red blood cells do not contain DNA, so forensics have to extract DNA from white blood cells

EXPLAIN IT TO A FRIEND

1. YOUR DNA IS UNIQUE

DNA is a very long molecule that contains the instructions for living things to build and maintain themselves. All organisms have their own unique strands of DNA in each cell, which forms a very long code known as their genome.

2. CELLS READ THE GENES

Certain stretches of an organism's genome do certain things. These sections are called genes. Each cell can 'read' the code written in the genes and use it to build all the chemicals it needs.

3. DNA EXISTS IN CHROMOSOMES

Within each cell, DNA is kept in packages called chromosomes. We inherit 23 chromosomes from our mother and 23 from our father. Which ones our parents pass on to us determines many things, including what we look like, what diseases we are likely to get and even some aspects of our personality and behaviour.

Does DNA enable evolution?

The fact that DNA can replicate itself is central to the evolution of all life on Earth. When early organisms replicated themselves, imperfections in the DNA copying process created new life with variations in their genetic code – leading to slightly different characteristics and features in each generation.

Any characteristics that gave an advantage to the organism were more likely to survive and be passed on. Organisms that were hindered by their variations would be more likely to die or not reproduce.

Over generations, the successful DNA sequences flourished and replicated, while the not-so-good DNA sequences were consigned to the evolutionary dustbin.

Life on Earth became increasingly varied and complex, with the most successful variants in each generation passing their genes on to the next. Charles Darwin described this as 'natural selection', long before DNA was discovered.

What can we do with DNA

We already use DNA for a range of immensely useful applications that can tell us about our past, present and future: what our ancestors were like, what medicines we should take or avoid, and what illnesses we may develop many years from now.

We can also use it to settle paternity disputes, or catch criminals, by searching for tiny amounts of DNA found at a crime scene.

But that's just the start. As DNA sequencing becomes vastly easier and cheaper, what was once unthinkable is now eminently possible. Already, scientists can create personalised medicines that are tailored to work with your exact combination of genes. They are reading the genomes of cancer cells, in order to learn more about them and fight them. Gene therapy can be used to fight genetic disorders by inserting new genes into people's DNA.

In the future, biologists may be able to create entirely new organisms

that exist solely to produce useful products for us. We may even be able to edit the genome of our offspring – not only to guarantee our children are free from genetic disorders, but also to ensure they have the characteristics we want. ■

TOM IRELAND is a science journalist and managing editor at the Society of Biology

DISCOVER MORE!

Listen to *DNA's Third Man* to discover more about Maurice Wilkins <http://bbc.in/1BMtHLe>

Do you love the natural world?
DNA helps biologists understand
how every living thing on Earth
got here. #genetics #biology

IN ONE TWEET! 

FREE GUIDE

Which Stairlift- is right for you?

At last!

The UK's first truly independent guide to stairlifts. Inside this 28 page colour booklet you will find everything you need to know about stairlifts, including :-

WAS £4.99
NOW FREE

BRAND NEW
2015
■ EDITION ■

- The huge difference a stairlift can make to your enjoyment of life (and those that live with you as well)
- How easy to operate and reliable the new modern stairlifts are
- How neatly the new designs fit in and can be adapted to harmonise with your home's surroundings
- What design features are available in terms of safety, comfort, accessibility, compactness and ease of operation
- How quick & easy it is to fit a stairlift – no matter how complex the stair layout
- The traps to avoid when buying a stairlift
- A comprehensive listing of all the major makes and models in the U.K. along with design options and special features
- How and where to get the best deals including reconditioned and renting options

Making the right decision

There's so much to think about when considering which stairlift is best for you. Where can you find truly independent, honest, objective advice you can trust? The only way is to learn all the facts and options available to you before you speak to any company. That's why The Consumers Guide to Stairlifts has been written by experts to give you truly impartial advice on every aspect of stairlifts... without fear or favour. So you can make informed decisions and discuss the issues with family and friends in the comfort of your own home. It will also tell you where to find the right stairlift for you at the best price. For your free copy of our new 2015 edition please **FREEPHONE 0800 074 3961** or **FREEPOST** the coupon right today.



Get your FREE 28 page full colour guide now - while stocks last!

FREEPOST: Mobility Aids Information Service (SL932FG) FREEPOST LON15651, London SE1 1BS

www.mobinfo.co.uk

The consumers guide to
Stairlifts

The UK's
first truly
independent
guide

Which Stairlift is
...for you?



2015
EDITION

STRAIGHT **OR** CURVED?

28
PAGES

32
MODELS



For your FREE copy - FREEPHONE

0800 074 3961

Lines Open
8am-8pm Mon-Fri
10am-4pm Sat-Sun
(QUOTE SL932FG)

Please send me my FREE Consumers Guide ☐

THIS BOOK WILL ONLY BE SENT TO THOSE APPLICANTS WHO SUPPLY THE CORRECT INFORMATION TO ALL SECTIONS MARKED * IN BLOCK CAPITALS

* MR/MRS/MISS _____

* ADDRESS _____

* POSTCODE _____ D.O.B DD MM YY

* TELEPHONE NUMBER (we cannot despatch without all details)

* _____

* MOBILE _____

* EMAIL _____

✉ PLACE THIS COUPON IN ENVELOPE & FREEPOST TO:
Mobility Aids Information Service (SL932FG)
FREEPOST LON15651, London SE1 1BS

The information we send you will be from our authorised associate for your area. If you do not wish to receive 3rd party marketing information by mail, phone, or otherwise please advise.

TO DO LIST

PLAN YOUR MONTH AHEAD WITH OUR EXPERT GUIDE

-  **WATCH**
-  **LISTEN**
-  **TOUCH**
-  **VISIT**
-  **READ**

PICK OF THE MONTH



Make It Digital

➔ IMAGINE A WORLD without computers. No smartphones. No internet. No videos of cats playing the piano. Over the past 30 years, computers have revolutionised our lives.

So how did we get here? And where are we headed? Make It Digital is a new BBC initiative that's aiming to shine a light on our digital world, with the hope of inspiring a whole new generation of computer programmers and tinkerers. You've probably already heard of the micro:bit – a coding device that's going out to one million children across the UK (read more about it on p79) – but there's a whole raft of goodies planned for TV too.

Budding computer whizzes could do worse than follow in the footsteps of Lady Ada King, Countess of Lovelace – or Ada Lovelace as she's usually known. Daughter of Lord Byron, Lovelace created what's considered to be the first ever computer program. In *Lady Ada Lovelace: Enchantress Of Numbers* (BBC Four), Dr Hannah Fry tells the extraordinary story of this early computer pioneer.

Today, algorithms are everywhere. They determine the products we buy, the articles we read, and even the people we socialise with. In *The*

Wonder Of Algorithms (BBC Four), Prof Marcus du Sautoy lifts the lid on this hidden realm, revealing the algorithms that guide our lives.

Sadly, computer science is often seen as a man's domain. *Girls Can Code* (BBC Three) aims to shatter this myth once and for all. The technological talent show will look for six girls with a gift for programming, presenting them with a series of coding challenges that would have even Alan Turing quaking in his boots.

Turing is a name that's synonymous with codebreaking, but have you heard of Gordon Welchman? As a fellow codebreaker at Bletchley Park, he made crucial contributions that helped shorten WWII by two years. But he's since been largely written out of history. *Gordon Welchman – The Forgotten Genius Of Bletchley Park* (BBC Two) will give him some long overdue recognition.

JAMES LLOYD



Look out for the Make It Digital season this September. See radiotimes.com for full details

DON'T MISS!



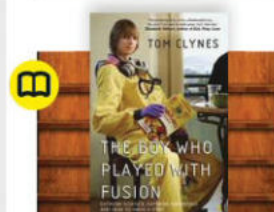
YouTube Revolution

YouTube was created 10 years ago, and now we can't get enough of it. **p94**



British Science Festival

Meet some well-known science names at this exciting event in Bradford. **p97**



The Boy Who Played With Fusion

We chat to Taylor Wilson, who achieved nuclear fusion as a teenager. **p98**



WATCH

TV & ONLINE

WITH JAMES LLOYD

SEPTEMBER

Six Degrees

BBC Two, September, dates TBC



Brian Cox: connected to you (and me!)

INSPIRED BY THE idea that everyone is no more than six acquaintances away from everyone else, Prof Brian Cox (pictured left) presents a one-off panel show exploring the unlikely scientific connections underpinning our lives. He's joined by guests including Ben Miller, Prof Alice Roberts and Prof Jim Al-Khalili. Kevin Bacon, sadly, won't be present.

FROM 1 SEPTEMBER

Animal Fight Club

Nat Geo Wild, 8pm



"Nick my Frosties, would you?"

BRAD PITT AND Edward Norton have nothing on these brawling beasts. Enormous cats clash in a whirlwind of teeth and claws, brown bears bicker over tasty salmon, honey badgers hustle, two Siamese fighting fish live up to their name, and even tiny shrews prove that size isn't everything. Just promise not to talk about what you've seen.

15 SEPTEMBER

Sir David Attenborough: A Life On Earth

Eden, 6pm



Sir David continues to inspire

OVER SEVEN DECADES, Attenborough has created a body of natural history work that will probably never be bettered. This one-off film sees the broadcasting legend talk to Australian journalist Ray Martin, with footage from Sir David's iconic series peppering conversations about his childhood, his endless passion for nature, and his early days in television.

JAMES LLOYD is the editorial assistant at *BBC Focus Magazine*



Psy's *Gangnam Style* became the first YouTube video to achieve one billion views

3 SEPTEMBER

YouTube Revolution

National Geographic, 9pm

BACK IN 2005 – when Justin Bieber was still at school, and twerking in public would probably have got you arrested – the very first video was uploaded onto YouTube. Titled *Me At The Zoo*, it featured the site's co-founder Jawed Karim in front of a pair of elephants at San Diego Zoo. As far as videos go, it's not exactly *Game Of Thrones*, but it paved the way for a digital phenomenon.

YouTube Revolution looks back at the first 10 years of this pioneering website, from its inception as a video-based dating service to the world-changing platform it is today. YouTube now has more than one billion users, with a whopping 300 hours of video being uploaded to the website every single minute.

Find out how three former PayPal employees created the site, and how the public embraced the opportunity to broadcast themselves to the globe. We also get an intriguing insight into the psychology of video sharing. What is it that makes a particular video go viral? *Charlie Bit My Finger* – probably the most famous home video on the planet – has had more views than the first Moon landing.

Meanwhile, we meet the amateur scientists who delighted millions with their Diet Coke and Mentos experiments, and hear what South Korean popstar Psy makes of his meteoric rise to fame. Rumour has it that some rare footage exists of the *Focus* team in full *Gangnam Style* mode...

DON'T buy a Hearing Aid until you've read this **ESSENTIAL** **FREE** Guide!

WAS £5.99 NOW FREE

INSIDE: Everything you need to know about hearing aids.

In the last ten years, new technology has created a maze of choices in the selection of hearing aids.

With more people than ever using hearing aids, it is essential that you have a reference to what hearing aids are about. There is far more to it than buying a pair of glasses.

The introduction of digital chip techniques has brought more features than existed under the old days of analogue hearing aids.

The options that come with a hearing aid – circuit configurations, channels, feedback cancellations

and more – can be puzzling to say the least.

The Consumers Guide To Hearing Aids is an A4 colour guide with 32 thorough pages which tell you everything you need to know about hearing aids.

It is the A-Z of Hearing Aids and can help you select the specific make and model which is best suited for your hearing loss. It explains what you spend your money on and can save your hard-earned cash before you buy a hearing aid. It gives you comparisons of hearing aids by brand, circuit option and model. This offer is only available to those who have a genuine hearing problem and is therefore limited to one copy per household.



Compare the market...

- Explains if you need a hearing aid and what it can do for you.
 - 24 Worldwide Brands.
 - Whether you need one or two hearing aids.
 - Digital Hearing Aid Technology explained.
 - Entry and Basic Level Digital Hearing Aids.
 - Advanced Digital Hearing Aids.
 - Premium Digital Hearing Aids.
 - Has an excellent section on common questions and answers.
 - Why Open Ear Hearing Aids are satisfying customers.
 - Definitions of Hearing Aid Terms.
 - What is Directional-Microphone Hearing Aid Technology.
- and much, much more.**

POST TO: Digital Hearing Aids Information Service (A839DCG) FREEPOST LON15651, London SE1 1BS



NEW 2015 EDITION

FREEPHONE 0800 074 3960

QUOTE A839DCG

Lines open 8am-8pm Weekdays. 10am-4pm Weekends.

to receive it by post fill in & send the coupon below or request details at

www.dhais.co.uk

Please send me my FREE Consumers Guide

PLEASE COMPLETE ALL SECTIONS MARKED * IN BLOCK CAPITALS.

*MR/MRS/MISS

*ADDRESS

*POSTCODE

*D.O.B

D D M M Y Y

*TELEPHONE (we cannot despatch without all details)

*MOBILE

*EMAIL

Digital Hearing Aid Information Service (A839DCG) FREEPOST LON15651, London SE1 1BS

Certain hearing aids may not help all types of hearing loss. The information we will send you will be from our authorised associate for your area. If you do not wish to receive additional information by mail, phone, email or otherwise please advise.



LISTEN

BBC RADIO PROGRAMMES

WITH JAMES LLOYD

TUESDAYS

Natural Histories

BBC Radio 4, 11am

THERE'S STILL TIME to catch Brett Westwood's fantastic wildlife series. This month, he's looking at daffodils, birds' eggs, bears and bramble, illuminating the intricate relationships between humans and the natural world. Head to the *Natural Histories* website for more episodes, plus facts and quizzes galore: <http://bbc.in/1KOLGkE>

26 AUGUST

3D Bioprinting

BBC World Service, time TBC

HOWARD STABLEFORD investigates the exciting new field of 3D bioprinting, finding out how scientists are able to print using living cells, and whether the technique could bring species back. If they make a 3D-printed dodo, we'll be first in the queue.



3D printing could revolutionise biology

FROM 31 AUGUST

Life-Changers

BBC World Service, time TBC

FOR EVERY Z-LIST celebrity, there a scientist or doctor who's changing the world. In this new four-part series, Dr Kevin Fong meets a doctor who's transforming care in Africa, a Nobel Prize-winning biologist, an aerospace engineer who helped to land Curiosity on Mars, and an exoplanet hunter.



Dr Kevin Fong meets real-life heroes

31 AUGUST

The Forum: Steel

BBC World Service, time TBC

BRIDGET KENDALL PRESENTS a guide to steel, the versatile and hard-as-nails material that keeps the world from falling apart. We hear from a steel scientist, an artist who creates colossal sculptures, and a steel pan expert. You'll never look at cutlery in the same way.

ONLINE

The Human Zoo

bbc.co.uk/programmes/b06106fr

CATCH UP WITH Michael Blastland's exploration of that most peculiar and unpredictable of species – us. In the latest series, he probes the unwritten rules that govern our behaviour and asks how often we actually listen to advice.



TOUCH

SMARTPHONE & TABLET APPS

WITH KATE RUSSELL

Ultimate Dinopedia

iOS 6.0 or later, iPad, National Geographic, £3.99



KIDS LOVE PLAYING with mum or dad's iPad. I've yet to meet one that doesn't love dinosaurs too. This app wraps the two things up brilliantly with an encyclopaedia stuffed full of images, sounds, animations and educational content. It's split into meat-eaters, plant-eaters, a discovering dinos section, and an A to Z, allowing young palaeontologists to swipe their way through the 150 million years that these impressive creatures ruled the Earth. It even comes with a dramatic voiceover guy who wouldn't be out of place introducing a wrestling match.

EarthViewer

iOS 4.0 or later, iPad, Howard Hughes Medical Institute, free



EXPLORE EARTH'S GEOLOGICAL past with an interactive globe that tracks the movements of the continents over the eons. You can turn on tags to view geological, biological and impact events, as well as mass extinctions. You can also find out more about the origin of significant fossils. Modern cities in key locations are handily tagged as landmarks to make it easier to see how the planet's surface has changed across years of continental drift. You can tap on the links to open text features and information boxes containing relevant data, while the tutorials and suggestions for classroom use make it a great study aid for schools.

NoiseTube

iOS 7.0 or later, iPhone/iPad/iPod Touch, Android 4.0 or later, Software Languages Labs, free



URBAN SPACES ARE noisy, but just how noisy is something researchers in Brussels want to find out with the help of your smartphone. Download the app and when activated it will monitor sound around you, recording the GPS location and feeding the information back to the researchers. You can tag the timeline with events when there are unusual noise spikes, like a plane overhead or a car horn blaring. Over time you will see a map of noise pollution building up.

KATE RUSSELL is a technology journalist and *Click* presenter



VISIT

EVENTS & EXHIBITIONS

WITH JHENI OSMAN



27 AUGUST

The Great Eclipse Expedition Mystery

Royal Observatory, London, 7pm-8:30pm, £7, rmg.co.uk

JOIN ROYAL OBSERVATORY astronomer Tom Kerss as he delves into the 1922 Australian expedition that tried to confirm the experimental 'proof' of Einstein's theory of General Relativity.

5 SEPTEMBER

Autumn In The Urban Meadow

National Museum, Cardiff, 11am-4pm, free, museumwales.ac.uk

DISCOVER HOW TO collect seeds from plants, take part in a seed swap event and find out how to entice wildlife into your garden.



UNTIL 6 SEPTEMBER

Statues From Easter Island

Manchester Museum, free, museum.manchester.ac.uk

RESEARCH CLAIMS THE Easter Island statues were 'walked' to their coastal resting places. Check out one of these iconic statues and discover why they were created in the first place.

UNTIL 6 SEPTEMBER

Wales's Newest Dinosaur

National Museum, Cardiff, free, museumwales.ac.uk

SEE THE OLDEST Jurassic dinosaur ever found in the UK. It was discovered at Lavernock in 2014 and is a predecessor to *T. rex*.



10 SEPTEMBER

Westworld

Royal Observatory, London, 7pm-9pm, £8, rmg.co.uk

WATCH THIS SCI-FI movie by Michael Crichton, in which a Wild West amusement park goes awry when a robot malfunctions.

15 SEPTEMBER - 20 OCTOBER

Introduction To Astronomy

Royal Observatory, London, 7pm-9pm, £78, rmg.co.uk

DO YOU STRUGGLE to tell the difference between comets and asteroids? This course runs for six weeks and gives a great introduction to all things astronomical.



Meet Dallas Campbell at the British Science Festival this month

EDITOR'S CHOICE

7-10 SEPTEMBER

British Science Festival

Various locations, Bradford, 10am-7pm, free, britishsciencefestival.org



WHAT GREAT INVENTIONS are set to change our future? Join leading academics to discover, discuss and debate the latest ideas and innovations at a huge selection of talks, performances and events from across the scientific spectrum. Highlights include Living On The Planet Of The Machines, Laughter Is The Best Medicine, The Rosetta Mission, and The Secret To Sporting Success. Plus, there are some well-known science names on hand, including BBC presenter Dallas Campbell in Dallas In Wonderland: Adventures In Science Television.

UNTIL 20 SEPTEMBER

In A Spin

Life Science Centre, Newcastle, entry included in admission, life.org.uk

WATCH OUT FOR spinning buckets and bike wheels behaving oddly at this live science show that explores the weird world of physics.



25 SEPTEMBER

Science Uncovered

Natural History Museum, London, 3pm-10:30pm, free, nhm.ac.uk

ENJOY A DRINK with the scientists that are usually beavering away out of sight, then have a sneak peek behind the scenes.

28 SEPTEMBER

Volcanoes And Us

Royal Society, London, 6:30pm-8pm, free, royalsociety.org

JOIN RADIO 4'S *The Life Scientific* host Jim Al-Khalili as he quizzes volcanologist Prof Stephen Sparks about his work, such as disaster response in Montserrat and aviation emergencies over Iceland.



READ

THE LATEST SCIENCE BOOKS REVIEWED

H Hardback **P** Paperback

The Boy Who Played With Fusion

Extreme Science, Extreme Parenting And How To Make A Star

Tom Clynes

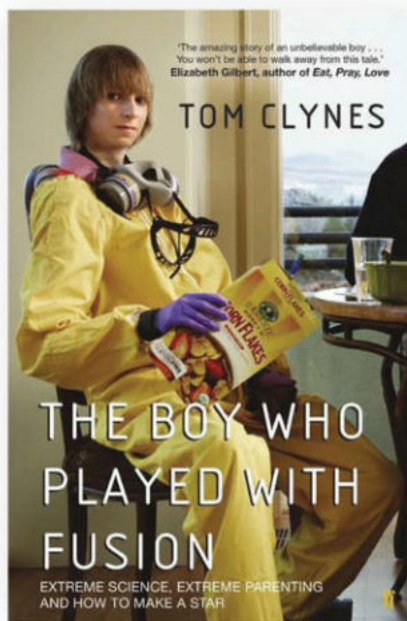
Faber & Faber **H** £16.99

SOME BRANCHES OF science are stashed away by public perception on a special shelf labelled: 'only to be touched by a certified genius'. Nuclear fusion is right up there with rocket science. So the claim made by the title of this book, that a mere boy could play with fusion, is worth some examination.

The book tells the story of Taylor Wilson, an intelligent Arkansas teenager who was for a while the youngest person ever to have achieved nuclear fusion. Tom Clynes weaves together the story of how Taylor's unusual abilities and enthusiasm soared as a result of his exceptional family and educational situation. But the best bits are the studies of the US education system, the amateur science community and the historical context, along with their implications for future research and innovation.

I got tired very quickly of the sycophantic descriptions of Taylor jumping up and down and telling people about science whether they were interested or not. The vast amount of help that Taylor got along the way

"It's exceptional and laudable for someone so young to be determined enough to achieve so much"



was almost hidden (I'm an experimental physicist and the author isn't, so maybe it was more obvious to me), and Taylor's foibles were highlighted as delightful idiosyncrasies. I accept that this was written for a US audience who are probably much more eager than the British to hear simplistic stories of heroes. I should also admit that I was put off by the implication on the cover that this book could be used as a parenting manual.

Clynes's brilliant journalistic instincts reappeared during the second half of the book, and the bits that I enjoyed most were those that didn't mention Taylor at all. There was an honest and informative examination of current trends in educational development and the ethics of dealing with differing needs (including what 'gifted' actually means). He also reminds us that the internet age made this story possible.

Even though very little of what Taylor has achieved is novel, there is no doubt that it's exceptional and laudable for someone so young to be determined enough to achieve so much. If you can hold your nose and deal with the sickly hyperbolae, then this is worth reading as a thoroughly researched case study.



HELEN CZERSKI is an oceanographer, physicist and BBC science presenter

MEET THE MAN



Taylor Wilson

Can you tell us about the fusion reactor you built?

I got into nuclear science when I was about 10 years old, and a year or two later I decided I wanted to start producing these nuclear reactions myself. My nuclear fusion reactor used a concept called 'inertial electrostatic confinement', which uses electric fields and very high temperatures to confine and fuse hydrogen ions [charged atoms]. But for me that was just the start – it's where all the other experiments began.

What have you worked on since?

I have a variety of programmes and projects underway, and they all revolve around nuclear physics. I developed a low-cost system for detecting [smuggled] nuclear material on a cargo container, and medical technologies for producing isotopes used in treating and diagnosing cancer. I'm also looking at power sources – both nuclear fusion and nuclear fission.

What's a typical day like for you?

The majority of my time these days is split between science and the more mundane business side of things. But what I enjoy most is being in the lab and conducting experiments. I try to build up the resources so that I can have an idea in the morning and then go in the lab in the afternoon to test it out.

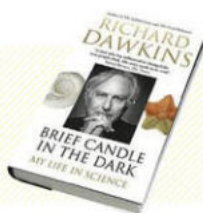
Is there anything else you'd particularly like to do?

Space science is fascinating to me, and hopefully I'll have a way to impact that through nuclear power sources, which I think are what we need for exploring our Solar System and beyond.



MORE ON THE PODCAST

Listen to the full interview with Taylor Wilson at sciencefocus.com/podcasts



Brief Candle In The Dark

Richard Dawkins

Bantam Press **P** £20

"IF YOU DON'T like digressive anecdotes you might find you're reading the wrong book," writes Richard Dawkins of *Brief Candle In The Dark*, a nostalgic romp through the gradual evolution of his scientific career. He serves up the quaint traditions of life as an Oxford don, is locked in Faraday's Room at the Royal Institution, delivers a series of theatrical Christmas lectures (including a piece involving "the creationist's favourite insect" the bombardier beetle), and gives the inside story on his experience of publishing and television.

Over the course of the 35 years covered in the book, Dawkins enjoys the warmth of dozens of luminaries. These include theoretical genius John Maynard Smith; fellow author and atheist Christopher Hitchens; and even Stephen Jay Gould, a man "whose genius for getting things wrong matched the eloquence with which he did so".

Die-hard Dawkins fans will find the close of the book particularly enjoyable, as it includes a lengthy reprise of his most important ideas and compelling metaphors. With great humanity and incomparable eloquence, Dawkins lays down his life for us all.



HENRY NICHOLLS is a science writer, editor and BBC radio presenter



EDITOR'S CHOICE

A Is For Arsenic

Dr Kathryn Harkup

Bloomsbury Sigma **P** £16.99

AGATHA CHRISTIE IS the most successful novelist of all time, so there's a chance your bookcase contains a smattering of her stories. Kathryn Harkup's *A Is For Arsenic* should sit alongside them.

Before she became a novelist, Christie was a pharmacist. She therefore had a detailed knowledge of the era's poisons, medicines and antidotes. She shared this insight with many of her villains, allowing them to dispatch victims with accuracy.

A Is For Arsenic makes for a cracking compendium of Christie's poisonings, by detailing a selection of novels and the chemicals used within them. Harkup describes how the poisons work and says whether Christie's details are accurate. Of particular interest are real tales of the poisons. These range from the possibility that Napoleon's ill health may have been caused from arsenic dye in wallpaper, to geriatrics lacing soup with atropine eye drops. Often, these real examples are stranger than fiction.

A Is For Arsenic will appeal to any fan of Christie's work, but as a potted history of poisons, antidotes and medicines it has much wider reach than that.

PS. Harkup carefully avoids giving away whodunnit.



DR MARK LORCH is a senior lecturer in chemistry at the University of Hull



Death By Video Game

Simon Parkin

Serpent's Tail **P** £12.99

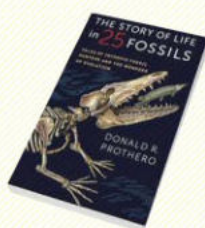
I WAS FULLY prepared to hate this book when I read the title. I am sick of hearing about how video gaming is to blame for so many of the bad things in modern life. But far from being a character assassination, this is a thoughtful and intelligent exploration of one of the biggest cultural phenomena of our times.

Grabbing the reader from the off with a rundown of some of the more high-profile gaming-related mishaps, the author asks what drives people to such extremes that they dedicate their life to controlling a bunch of pixels on a screen. Often, their obsession comes at the exclusion of all else, including personal hygiene, and in certain cases, death – both on-screen and off – is the final outcome.

Drawing on a long and distinguished career reporting on video game culture, Simon Parkin gracefully leads the reader towards considering what other, extenuating circumstances might be to blame. The cautionary tale of a family brought to destitution in the 1800s by a "reckless passion for novel reading" is the perfect example of how Parkin holds a mirror up to society, allowing even those with no personal gaming experience to gain insight into this global obsession.



KATE RUSSELL is an avid gamer and a technology reporter on *BBC Click*



The Story Of Life In 25 Fossils

Donald R Prothero

Columbia University Press **P** £24

TRYING TO CAPTURE the history of life, and all its glorious evolutionary wonder in just 25 fossils is an impossible job, and so it's no surprise that Donald Prothero hasn't quite managed it. But there is still a lot to like about this book (once we let Prothero off the hook for dedicating 18 of the 25 chapters to vertebrates, and only one to plants).

Most chapters end with a section describing the best places to visit if you want to see the fossils for yourself, which is a lovely touch. Prothero has also made a refreshing effort to include a number of female palaeontologists. I was

especially pleased to see Tina Negus's role in the Ediacaran discoveries mentioned, as well as a shout to Isabel Cookson. Each chapter is short and sweet, and great for dipping in to, but space was a little too limited to do justice to the rich history of discoveries alongside the science. As a result, it feels a little bit piecemeal. Nonetheless, the writing is clear and engaging, and the reader is spoiled by the number of well-chosen illustrations.



DR TORI HERRIDGE is a palaeobiologist at the Natural History Museum

The Northern Lights

Ever wanted to experience one of nature's great displays? The Aurora Borealis is one of the great, timeless thrills of travel, a beautiful dance of natural light that many viewers find a humbling and spiritually uplifting experience...



THE AURORA ZONE

EXCEPTIONAL HOLIDAYS ACROSS
FINLAND, SWEDEN, NORWAY,
ICELAND, GREENLAND AND CANADA

The Aurora Zone is the UK's original Northern Lights holiday company, and is the only tour operator solely dedicated to helping you achieve your goal of seeing the Northern Lights. The Aurora Zone offers an exceptional range of holidays across Finland, Sweden, Norway, Iceland, Greenland and Canada; combining carefully planned nights of Aurora hunting with unforgettable daytime activities such as dog sledding and snowmobiling. Guests can choose between either a relaxed, balanced or active pace for their holiday or they can tailor make an itinerary. The Aurora Zone works with expert local guides who use their extensive knowledge and experience to maximise your chances of seeing the Northern Lights.

TEL: **01670 785 048**

WEB: **www.theaurorazone.com**



NATURE TRAVELS

DOG SLEDDING & NORTHERN LIGHTS IN
SWEDEN & NORWAY

Nature Travels is the UK specialist for outdoor experiences in the Nordic countries. Wide range of dogsled tours 1-12 days in the far north of Sweden and Norway, from family-friendly tours to challenging wilderness expeditions. Sledding far from areas of light pollution gives very good chances to see the Northern Lights during your tour. Drive your own husky team through beautiful winter landscapes of snow-covered forest and frozen lakes, dogsled on the King's Trail in Lapland in stunning mountain terrain or sled across the Arctic tundra in Norway. Stay in wilderness cabins or winter camping along the route. Season November-April.

TEL: **01929 503080**

WEB: **www.naturetravels.co.uk**



THE MIGHTY FINE COMPANY

MAGIC BY DAY, MAGIC BY NIGHT

Travel with us to see the Northern Lights and your holiday will be as magical as the mystical Aurora Borealis! Your days will be just as exciting as your nights, exploring stunning landscapes on thrilling snowmobiles and husky safaris. Afterwards expert local guides will lead you to the best possible Northern Lights viewing spots. Plus when it comes to selecting your accommodation, you'll have a simply amazing choice, including the opportunity to sleep in a glass igloo and watch the magic overhead. If you love the Northern Lights, you'll love The Mighty Fine Company. Call us today and let the magic begin!

TEL: **0333 800 2033**

WEB: **www.mightyfinecompany.com**

ASTRONOMY



A wide range of optical instruments and accessories available for all levels of users.

An ideal gift for children and adults

- Telescopes
- Binoculars & Monoculars
- Spotting Scopes
- Microscopes

www.nipon-scope.com

Email: sales@nipon-scope.com



EDUCATION

PLANET EARTH EDUCATION



A popular and long standing provider of astronomy distance learning courses. All courses enjoy an excellent reputation and a certificate is awarded for each completed course. Students have easily accessible, one-to-one contact with their tutors. Five astronomy courses available:

- GCSE Astronomy - for a certificate
- PEC Nature of the Planets - learning for fun about the solar system
- PEC Nature of the Stars - learning for fun about the night sky
- PEC Astronomy - to GCSE standard but without the exam
- PEC Advanced Astronomy - for the more dedicated student

Also available: The Mobile Stars Planetarium – an exciting educational experience for children in schools and for scouting groups.

☎ 0161 653 9092 | www.planeteartheducation.co.uk

ASTRONOMY



Digital Microscopes

Micro Fi

Stream. Capture. Share.

Micro Fi is a Wi-Fi enabled handheld digital microscope that enables you to view the microscopic world right on your smartphone or tablet!



Celestron Microscopes are available from



01502 725205
and specialist dealers nationwide

TetraView™

The professional-level Celestron TetraView LCD is a touchscreen digital microscope with advanced features at a reasonable price. TetraView features four fully achromatic lens objectives, a fully mechanical stage, a 4.3" TFT full colour touch screen, 5 MP CMOS sensor, and a 2 GB SD card for storing your photos and videos. Taking high-resolution images and video of specimen slides has never been easier.

Handheld Pro 5MP Digital Microscope

Easy to use, low-power microscope with a large 5.0 MP sensor and stand.



Celestron is distributed in the UK and Ireland by David Hinds Ltd. Dealer enquiries welcomed.
David Hinds Ltd. Unit R, Cherrycourt Way, Leighton Buzzard, Bedfordshire LU7 4UH

Celestron® and TetraView™ are registered trademarks or trademarks of Celestron Acquisition, LLC in the United States and in dozens of other countries around the world. All rights reserved. Samsung is a registered trademark of Samsung Electronics Co., Ltd. AppStore is a registered trademark of Apple Inc. Google Play is a registered trademark of Google Inc.

See more with Celestron
www.celestron.uk.com

EDUCATION

Astronomy by Distance Learning

An Introduction to Astronomy Sept

NEW Science with the Liverpool Telescope Oct

Science of the Night Sky Nov



www.astronomy.ac.uk

astro-distance@ljmu.ac.uk 0151 231 2900

PUBLISHERS

LOOKING TO BE PUBLISHED?

SUBMISSIONS AND SAMPLES WELCOMED. ALL WORK CONSIDERED, NO AGENT REQUIRED.

AUSTIN MACAULEY
PUBLISHERS LTD.

CGC-33-01, 25 Canada Square
Canary Wharf, London, E14 5LQ

Tel: 0207 038 8212

www.austinmacauley.com

mail@austinmacauley.com

BESPOKE FURNITURE



IAN EDWARDS

OF HARROGATE Est. 1970

Tel: **01423 500442**

for sales/enquiries or FREE brochure call - 01423 500442

www.iansbespokefurniture.co.uk



Handmade Bespoke Furniture

for CD's • LP's • DVD's & Books

The Old Chapel, 282 Skipton Road,
Harrogate, Yorkshire HG1 3HE

SCIENCE GIFTS

DISCOVER NEW WONDERS OF DNA



AT THE
DNA STORE!

toys, balloons, neckties,
art, earrings, mugs,
models, coins, stamps,
cards, roadsigns, jewelry,
puzzles, most anything
you can imagine!

thednastore.com

dna.science

SCIENCE WORKSHOPS AND PARTIES



Fizz Pop Science™ deliver hands on 'Science Workshops' and 'Science Parties' for children aged 4 - 12 years. We make Science fun for everyone with 'WOW' factor shows and programmes that will have children gripped from the start.

We can deliver to your school/ Brownies/Cubs or children's group with our no fuss in school workshops and shows, or maybe it is your child's birthday and you wish to celebrate it with something a little different.

0845 5193932

www.fizzpopsience.co.uk | enquiries@fizzpopsience.co.uk

(Franchise opportunities also available see website for more information.)

Why Not Be A Writer?

What our students say:



"So far, I have had eighteen novels published!" The Writers Bureau helped make this possible for me. Within six months of enrolling on my course I was having work commissioned by editors and I still work regularly for magazines."

AWARD WINNING WRITER
Christina Jones, Oxfordshire



"I thought you'd like to know that seven years since doing my course at WB I've been published in more than **150 magazines** around the world. I've now got to the stage where I'm turning down all-inclusive exotic press trips!"

Cindy-Lou Dale, Kent



"Completing The Writers Bureau course has made it possible for me to attain my life-long ambition of becoming a published writer. The level of success I have achieved has far outweighed what I was hoping for when beginning the course. By the end of this year I should have **eight books already published** and hopefully two more finished."

Michael Foley, Essex



"The amount of hours I have been able to work have been limited but I have earned approx **£3,500** from my writing this year. I now regularly sell articles and am working on a book proposal."

Jane Redfern-Jones.



"I've had **30 pieces** of work accepted by various publications since I started my Writers Bureau course – a mere 18 months ago."

"I contemplate that fact and I am amazed to have come so far in such a short time, especially when I consider the severe restrictions on the time I have available for writing. I usually manage about three hours per week, if I'm lucky."

Chris Green, Lincolnshire

Being a writer can offer you a second income, extra spending money or even be a full-time career. It's your choice. But whatever your writing ambitions we have a course that will help you to achieve them.

That's because our first-class home-study creative writing course contains all you need to know to become a successful, published writer. You learn how to write articles, short stories, novels, TV, radio, drama and more. You are shown how to develop your writing style, present your manuscripts, contact editors, find markets and HOW TO SELL YOUR WORK.

What's more, **you do not need any previous writing experience** to succeed on the course as it's suitable for the absolute beginner.

Throughout the course you will be tutored by a professional writer, who will offer constructive feedback on your twenty marked assignments. In addition, you can count on the support of our dedicated Student Services team who will do all they can to ensure that you get the most out of your studies.

When you enrol, your full course is sent to you on a fifteen day trial. Your studies are then flexible to your requirements as you have four years to complete your course. Moreover, **we offer you a full refund guarantee**. If you do not earn back the equivalent of your fees by the time you finish your course we will refund them in full.

So, if you would like to learn to earn from writing, try our risk-free course. For a free prospectus visit our website or call our freephone number today!

www.writersbureau.com

FREE CALL
24 HRS

0800 856 2008

Quote ref:
JL25615

Please send me FREE details of how to become a published writer:

Name: _____
Address: _____
Postcode: _____
Email: _____

Freepost RSSK-JZAC-JCJG
The Writers Bureau
Dept JL25615, Manchester, M3 1LE



www.facebook.com/writersbureau
www.twitter.com/writersbureau



Members of BILD and ABCC

email: 15W1@writersbureau.com
Please include your name and address

Enrol online to access your course modules TODAY at: www.writersbureau.com

NEW FROM **FOCUS**

Do you want to live a longer, healthier and happier life? Of course you do... and here's a *BBC Focus* guide to doing just that. Our experts looked at the most up-to-date research and weighed up all the evidence to bring you **the definitive manual for living well in the 21st Century**. Find out:

- How **medicines** and **vaccines** have tamed previously fatal diseases
- Why many Western doctors now recommend **yoga** and **meditation**
- The truth about **caffeine**, sugar, red meat, **salt** and so-called '**superfoods**'
- How **bionic implants** and **robot nurses** are transforming healthcare

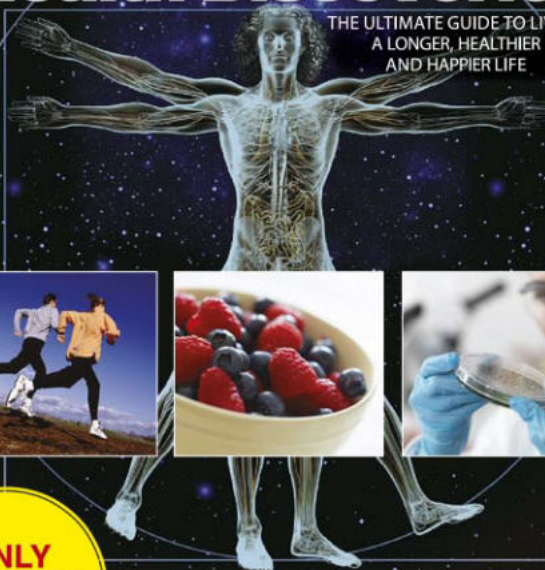
Plus – subscribers to *BBC Focus* receive **FREE UK POSTAGE** on this special edition!

BBC

100

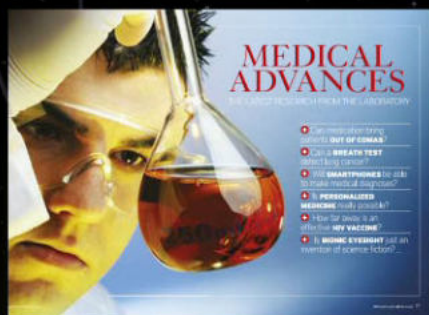
Breakthrough Health Discoveries

THE ULTIMATE GUIDE TO LIVING A LONGER, HEALTHIER AND HAPPIER LIFE



**ONLY
£9.99***

FROM THE EDITORS OF **BBC FOCUS**



Discover the startling new advances still being made in medicine today



The UK's top sports scientists help you get the most from your exercise regime



Mental health is important, too! Learn how to reduce stress and overcome your fears



Order online

www.buysubscriptions.com/focushealth



Or call our order hotline 0844 844 0257†

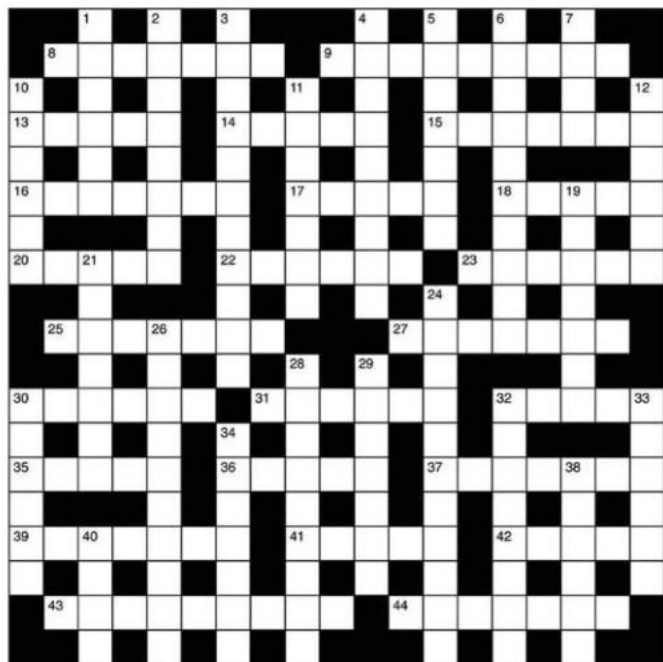
Please quote
FOCHA15

† Calls will cost 7p per minute plus your telephone company's access charge. Lines are open 8am-8pm weekdays & 9am-1pm Saturday.

*Subscribers to BBC Focus magazine receive FREE UK POSTAGE on this special edition. Prices including postage are: £11.49 for all other UK residents, £12.99 for Europe and £13.49 for Rest of World (please note this title is not available for direct order in the US or Canada but is available in all good retailers now). All orders subject to availability. Please allow up to 21 days for delivery.

FOCUS CROSSWORD No 181

More online Solve puzzles from BBC *Only Connect* hosted by Victoria Coren Mitchell at <http://bbc.in/1vCOzuY>



ACROSS

- 8 Check the lizard (7)
- 9 Element is excellent, taken into new university (9)
- 13 Digit with its own rule (5)
- 14 The topless student gets cricket team into shape (5)
- 15 Church role generated a complaint (7)
- 16 Tempered steel takes pressure and resistance, but it's impure (7)
- 17 Lime gets broken down around turn in intestine (5)
- 18 All right for a Greek character to have an animal (5)
- 20 Arachnid usually has a nest (5)
- 22 A chore, developing stem support (6)
- 23 Mathematician with his own strip (6)
- 25 Agreement against getting rope (7)
- 27 Bishop sees one revolution in transport (7)
- 30 Flexible current in organism (6)
- 31 Aliens work out a solution (6)
- 32 Each hybrid has large claw (5)
- 35 Cook pears with some asparagus (5)
- 36 Bean shows sign of life (5)
- 37 Uncle moved you and me to the centre (7)
- 39 A pickpocket is a problem, as is lack of thirst (7)
- 41 Gnats affected by worry (5)
- 42 Encountered a length of nickel, say (5)
- 43 Fortune-teller finds cream gone off (9)
- 44 Rules in English for analgesic (7)

DOWN

- 1 Firm rule about great circle (6)
- 2 Debate is about disorder (8)
- 3 Important part of circuit, relative to directors (11)
- 4 Let femur be reassessed with unknown gauge (9)
- 5 Finally graduate at a California desert (7)
- 6 Gloomy note about creepy study (10)
- 7 Turn up to create empty colour (4)
- 10 Mixed paints and grape juice (6)
- 11 Heard to insult skill (7)
- 12 Length of a bone (6)
- 19 Fabricating a lax lie is the pits (7)
- 21 I did work with bull at European compound (7)
- 24 Throw bait in Rhone, then have long sleep (11)
- 26 Played cornet a certain amount somewhere in cell (10)
- 28 Background that may be screened (9)
- 29 Cloth depicting king teeing off (7)
- 30 Claps wildly, taking a degree of pressure (6)
- 32 Plant two coppers next to doctor and queen (8)
- 33 Organising names, including Latin saint (6)
- 34 Otters do twist time (7)
- 38 Send text about article that's living (6)
- 40 Lie about getting kiss from Holly, say (4)

SOLUTION TO CROSSWORD No 178

Gordon Kirkland, Charles Caldwell, Ivor Dibble, Michael Moran and M Akehurst each solved issue 282's puzzle and receive a copy of *Deadly Dilemmas* (Go Entertain, £19.99).

WIN! SCIENCE BUT NOT AS WE KNOW IT

The first five correct solutions drawn will each win a copy of *Science But Not As We Know It* (Dorling Kindersley, £9.99).



Entries must be received by 5pm on 17 September 2015. See below for more details.



YOUR DETAILS

NAME _____

ADDRESS _____

POSTCODE _____

TEL _____

EMAIL _____

Post entries to *BBC Focus Magazine*, September 2015 Crossword, PO Box 501, Leicester, LE94 0AA or email a scan of the completed crossword or a list of answers to september2015@focuscomps.co.uk by 5pm on 17 September 2015. Entrants must supply name, address and phone number. Immediate Media, publisher of *BBC Focus Magazine*, may contact you with details of our products and services or to undertake research. Please write 'Do Not Contact' on your email or postal entry if you do not want to receive such information by post or phone. Please write your email address on your postal entry if you would like to receive such information by email.

TERMS & CONDITIONS

Entrants must be UK residents (inc Channel Islands) aged 18 or over. Immediate Media employees are not eligible to enter. By entering participants agree to be bound by these terms and conditions and that their name and county may be released if they win. Only one entry permitted per person. No responsibility is accepted for lost, delayed, ineligible or fraudulent entries. Entries received after the closing date will not be considered. Immediate Media (publisher of *BBC Focus Magazine*) will only ever use personal details for the purposes of administering this competition unless

you permit otherwise. Read more about the Immediate Privacy Policy at www.immediatemediamedia.co.uk/privacy-policy. The winning entrants will be the first correct entries drawn at random after the closing time. The prize and number of winners will be as shown above. The winners will be notified within 30 days of the closing date by post. Immediate Media's decision is final and no further correspondence relating to the competition will be entered into. If the winner cannot be contacted within one month of the closing date, Immediate Media reserves the right to offer the prize to a runner-up.

HOLLYWOOD SCIENCE

Nuclear weapons in **The Man From U.N.C.L.E.**

IN GUY RITCHIE'S new film, *The Man From U.N.C.L.E.*, secret agents Napoleon Solo and Illya Kuryakin must thwart a criminal gang working to proliferate nuclear weapons. But building your own nuclear bomb, fortunately, is not as easy as Hollywood makes out.

It all boils down to one equation, penned by Albert Einstein over 100 years ago. $E=mc^2$ describes how a tiny amount of mass can release a huge amount of energy, and is the principle that led US scientists to develop the destructive power of the atomic bomb. But this equation is also the name of Mariah Carey's 11th studio album... both these facts would probably have Einstein turning in his grave.

In a fission bomb, atoms are split to generate energy and neutrons, which can then split more atoms, releasing more energy and more neutrons and so on and so forth. Uranium – a naturally occurring heavy metal – is one starting material, but it

“As Hollywood knows, it's far easier for the baddies to let someone else do the donkey work”

contains a mix of different isotopes. One of the isotopes, uranium-238, makes up over 99 per cent of the material and cannot be split. But atoms of uranium-235, present in tiny amounts, can be blasted apart when bombarded with neutrons. A would-be bomb-maker must first 'enrich' the fissile fraction. "It's a very complex and expensive procedure," says nuclear physicist Phil Walker from Surrey University.

As Hollywood well knows, it's far easier for the baddies to let someone else do the donkey work, then steal the end product from them. Nuclear power plants use enriched uranium, but theirs contains less than 20 per cent uranium-235. To make a bomb, the figure needs to be closer to 80 per cent. Locate and nick around 60kg or so of this highly-enriched uranium – a very heavy suitcase-full – and the next step would be to detonate it using conventional explosives.



Here again, technical knowledge is at a premium. Get it wrong and the bomb might destroy itself before its critical mass is reached, get it 'right' and it might blow the baddies and the whole of Hollywood all the way to Bruce Willis's *Armageddon*. "It's not a 'man on the street' enterprise," says Walker. The average terrorist group couldn't do this on their own; they'd need specialist help from someone with expertise in ballistics, engineering and nuclear physics. "Kidnapping someone like me wouldn't do any good," says Walker, "I wouldn't know what to do." If history has taught us anything, it's that the tragedies of Hiroshima and Nagasaki should never be repeated... and that Mariah Carey should retire. Quietly. ■



HELEN PILCHER is a science writer and comedian. She tweets from @Helenpilcher1

dp0

Quattro

Reinventing the camera

Reinventing DP



Ultra-minimal distortion. Introducing the extreme dp.

A difficult-to-manufacture large-diameter aspheric lens sits first in the optical group, reducing distortion to less than 1% at infinity. Minimal distortion is critical to ultra-wide-angle performance. The 14mm F4 lens of the dp0 Quattro is designed to deliver an even wider angle-of-view than the dp1 and ultra-minimal distortion. The dp0 exemplifies the spirit of the dp Quattro series.

dp1 Wide
Quattro 19mm (28mm) F2.8

dp2 Standard
Quattro 30mm (45mm) F2.8

dp3 Mid-tele
Quattro 50mm (75mm) F2.8

SIGMA
sigma-global.com



OLYMPUS

Your Vision. Our Future

Olympus Cameras

A new perspective.

What has continued to motivate us over the years? Outstanding innovation that generates new perspectives and new possibilities.

The new OM-D E-M5 Mark II features the world's most powerful 5-axis image stabilisation system*, producing breathtakingly sharp images even in low light and shake-free movies, all without the need for a tripod.

*According to CIPA Standard 12/2014.

Discover more: anewperspective.olympus.co.uk